POWER PLANT ENGINEERING

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Lakeside Power Station at Milwaukee

MECHANICAL, ELECTRICAL AND CONSTRUCTION FEATURES OF WORLD'S LARGEST PULVERIZED FUEL BURNING POWER PLANT

PROBABLY no other plant in the country has attracted as much attention of engineers interested in power plant development as the Lakeside Station of the Milwaukee Electric Railway & Light Co., which was put into operation on Dec. 15, 1920. The feature of principal interest is that this is the first large power plant that has been especially designed and built for using exclusively pulverized coal as fuel. Being considerable of an experiment, the plant has proved an excellent laboratory for investigating best practice in the operation of pulverized fuel furnaces and much of the most recent developments in this class of equipment is due directly to experimental work carried on in this plant.

As a result of an increasing load demand the company decided in 1916 to build a new plant, the initial installation of which should have a capacity of 40,000 kw. with an ultimate capacity of 200,000 kw. The site selected was at St. Francis or Lakeside which is on the lake front about a mile south of the city limits of Milwaukee and not far from the load center of the territory which it will serve. The building site and necessary railway right-of-way for the spur track from the Chicago & Northwestern Railroad was, therefore, purchased and considerable progress was made at that time

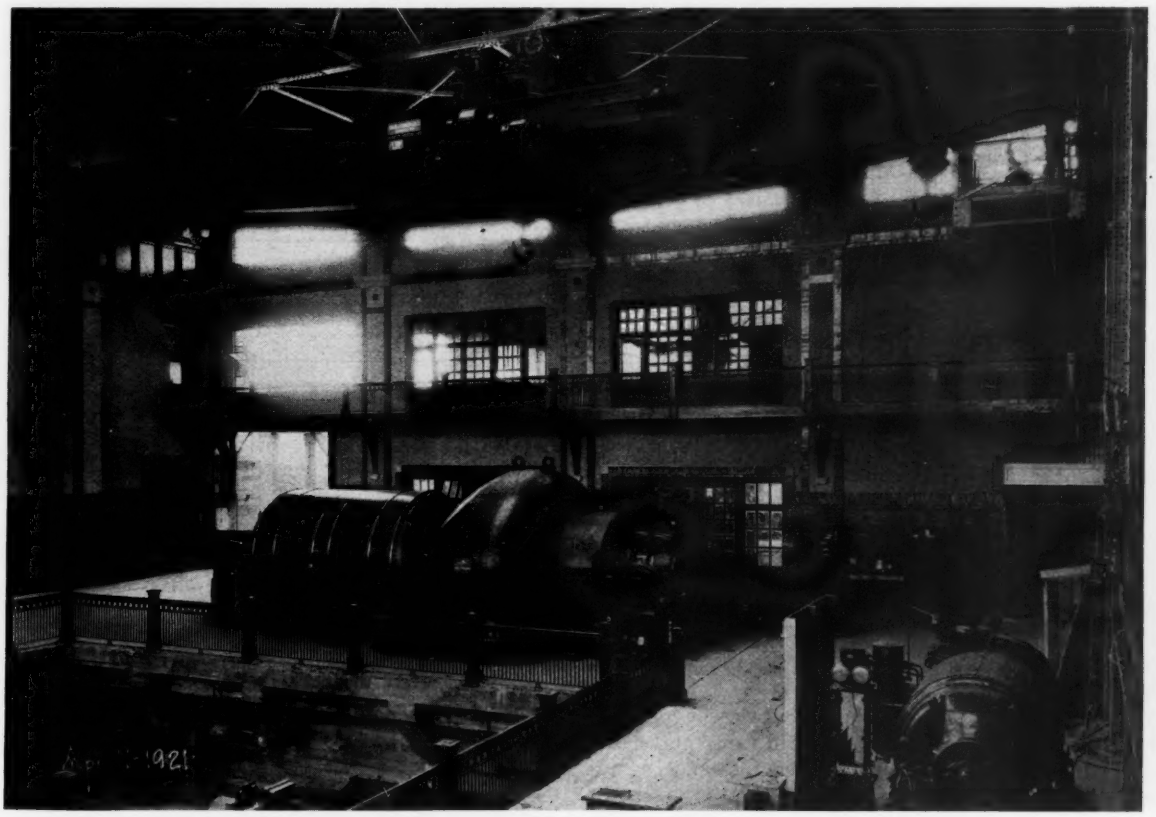


FIG. 1. VIEW OF TURBINE ROOM, SHOWING 20,000 KW. TURBO GENERATOR, UNIT NO. 1

with the engineering work and a great share of the machinery had even been ordered when war conditions made it imperative that all work on the new plant be suspended and it was not until Dec. 22, 1919, that orders were issued to the company's engineering department to proceed with construction work.

During the war, however, the zoning system of coal distribution which was enforced by the Fuel Administration compelled the company to use Illinois coal, which came to the plant in railroad cars, instead of the eastern coal which had formerly been the fuel used and which came to Milwaukee in barges. During this period, also, the company had done considerable experimenting with pulverized coal in its Oneida Street Station and when it was decided to go ahead with the construction work of the new plant, the results which had been obtained with this type of fuel caused the engineers to change their plans for the plant entirely and equip it for burning pulverized coal instead of putting in stokers as was planned in the first place.

Such a radical change as this necessitated a great amount of engineering work, much of which was carried on almost simultaneously with the construction. The severe winter weather, scarcity of labor and delayed deliveries were also among the adverse conditions which had to be met, but notwithstanding all this the plant was in operation in less than a year and has seen continuous service ever since.

In addition to the fact that the Lakeside plant is the largest central station in the world using pulverized fuel exclusively, the company's engineers who are responsible for the design of the plant have shown originality and ingenuity in the design of the circulating water system which includes the rubble mound enclosure in the lake and the 10-ft. intake and discharge tunnels with their controlling gates, screen chamber and screens, and in locating the plant in a deep excavation with the attendant necessity for retaining walls and heavy foundation work.

General Plan

Four distinct sections are comprised in the complete plant. These are the pulverizing room, which is an entirely separate building at the east side of the premises reaching to the edge of the lake bluff, the boiler room to the west, the turbine room with adjoining machine shop and offices, and the switchhouse at the extreme west end adjacent to the concrete State road. Future extensions will be made to the south, the walls on this side being of temporary construction. The general level of the ground at this location is about 50 ft. above the lake level with a deep bluff at the lake shore and to economize in power for pumping condensing water it was decided to locate the condensers at an elevation which would require a minimum of lift of the condensing water. The suction chamber was therefore located at lake level and this determined the elevation of the condensers and consequently that of the turbines and boilers.

The deepest excavation required was to an elevation 20 ft. below lake level for turbine foundations and intake chamber, placing the main condenser floor at elevation

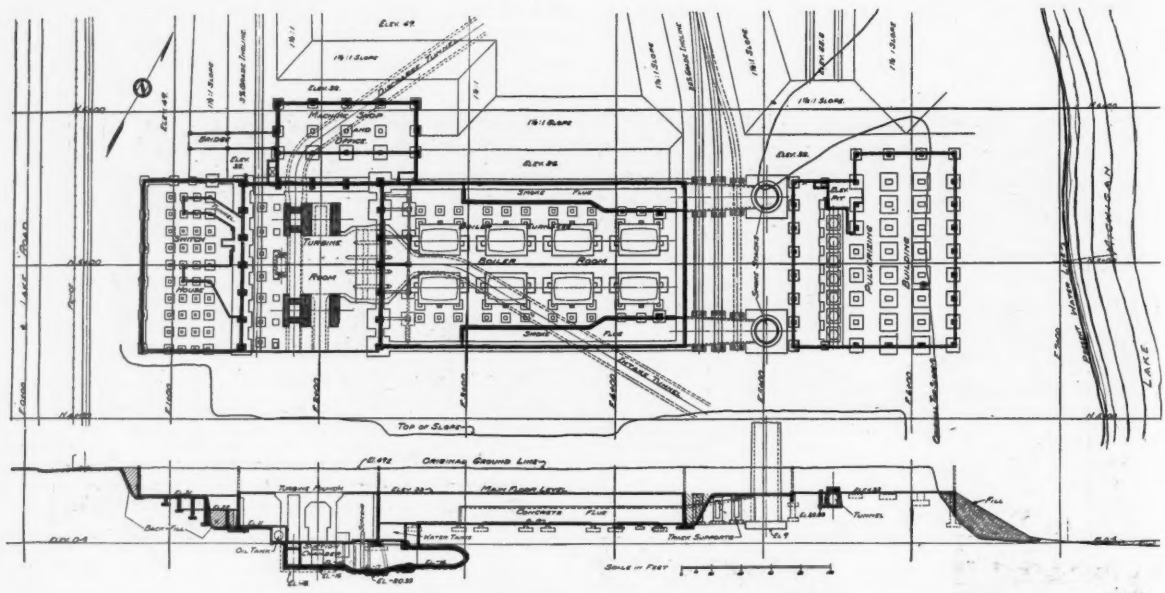


FIG. 2. FOUNDATION PLAN AND LONGITUDINAL SECTION

+ 1 and the main boiler and turbine room floors at + 32 or about 18 ft. below the ground level.

Because of this location of the plant, practically all of the outside walls of the buildings had to be designed as retaining walls, the horizontal component determined upon being 30 lb. per sq. ft. per foot of depth and 6000 lb. per square foot was used as the soil-bearing strength.

Above the foundations the main buildings are of the usual fireproof construction; the switchhouse, office and machine shop buildings being constructed with reinforced concrete frames; the turbine room, boiler room and pulverizing building having steel frames; the coal dumping and crushing structures are of reinforced concrete construction throughout. The main buildings have brick walls faced with red pressed brick, trimmed with stone, and have concrete slab roofs covered with

tar and gravel roofing. Over the turbine room and switchhouse a layer of 3-in. hollow tile is placed above the roof slab to prevent condensation which might otherwise occur here. The interior of the turbine room is faced with straw colored glazed brick trimmed with brown enamel brick and cut stone, and the floors of the operating portions of the switchhouse, office, turbine and boiler rooms are of terrazzo and red quarry tile.

Coal Handling and Pulverizing

Coal comes to the plant by rail on the company's private sidetrack, being removed from the cars by means of a rotary car dumper of the Robins-Scherzer type and dropped into a track hopper fitted with bottom shaker feeders. In case the coal is delivered in cars of the drop bottom type, it may be unloaded into the same hopper from a railway track placed beside the one on which the rotary dumper is located. Belt conveyors carry the coal from the track hopper over a magnetic pulley which takes out the tramp iron, then pass it to a two-roll crusher and hammer mill. The crushed coal is received by a belt which carries it to the distributing belts over the coal bunker in the pulverizing plant. Distribution is done by three belts, each having a traveling tripper which discharges coal at any desired point along the length of the belt.

The crusher and hammer will have a capacity of 150 T. of mine run coal per hour and the belt conveyors, which are 36 in. wide, will handle 250 T. per hour when run at 250 ft. per minute. Provisions have been made in the building for the installation of another crusher unit which will double the present capacity when future requirements demand.

Storing of coal coming to the plant by rail will be provided for in the future. The plan is to bypass the crusher and convey the coal by belt to the dock, where it will be taken up by a coal bridge and stored. Reclaiming the coal will be accomplished by reversing operations and delivering it to the crushers. Coal coming to the plant by boats will follow the same course when docking provisions have been made. The entire coal handling equipment is the product of the Robins Conveying Belt Co.

From the car-dumping and crushing plant to the pulverizing plant is about 400 ft. and the conveyor belt runs in an inclined housing between the two buildings, delivering the coal to the green coal bumper which occupies nearly the entire upper part of the pulverizing building.

The pulverizing plant covers an area 108 by 125 ft. and is equipped to prepare the coal for a plant of 80,000 kw. capacity. The bunkers have a capacity of 3400 T., which is slightly more than three-and-one-half days' supply for maximum operation of all boilers in this section. Three screw conveyors take the coal from the bunkers to automatic weighing scales, thence another set of screw conveyors feed into the dryers. With this arrangement it is possible to take coal from any point in the bunker and deliver it to any one of the three dryers. It also allows the coal to be weighed just before reaching the dryers, permitting a close check on the daily coal consumption of the plant.

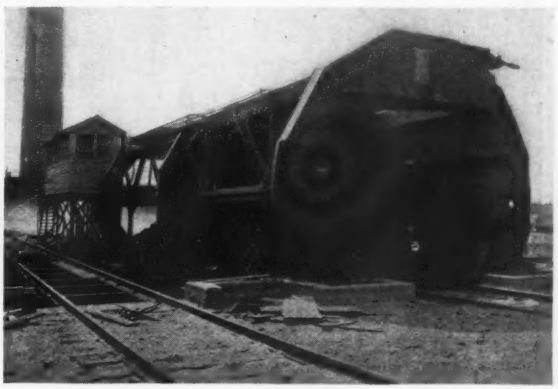


FIG. 3. ROTARY CAR DUMPER IN DUMPING POSITION

Each of the three Fuller-Lehigh dryers has a capacity of 10 T. per hour when reducing the moisture in the coal from 10 to 2 per cent. Screw conveyors take the coal from the dryers to bucket elevators which in turn discharge to other screw conveyors to be transferred to dried coal bins over the pulverizing mills.

Eight 46-in. Fuller-Lehigh air separating unit pulverizing mills are installed, each having a capacity of 6 T. per hour when reducing the coal in size so that 75 per cent will pass through a 200-mesh screen and

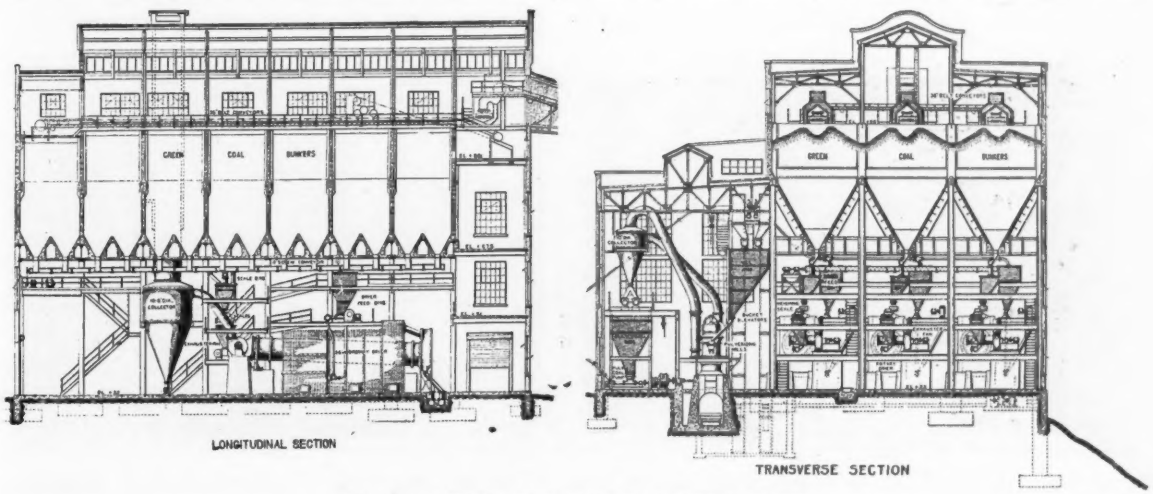


FIG. 4. SECTIONS THROUGH PULVERIZING PLANT

90 per cent through a 100-mesh screen. Each of the mills is driven by a 100-hp. motor, and a fan is also provided for each mill for separating the pulverized particles which have been reduced to the necessary fineness and discharging them into cyclone separators overhead where the fuel is separated from the air and falls by gravity into a screw conveyor located at the base of

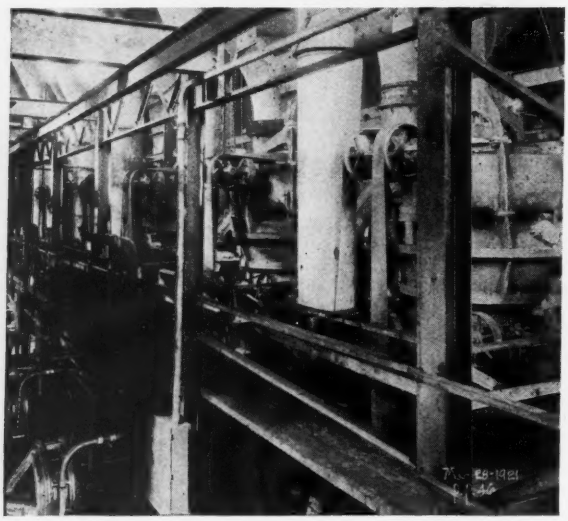


FIG. 5. PULVERIZING MILLS, COAL PULVERIZING PLANT

the separators which conveys it to the pulverized fuel bins.

Delivery from these bins to the bins in the boiler room is by means of the Fuller-Kinyon pumping system of transporting pulverized material.

Boiler Room

To supply steam for the first section of the plant eight 1306-hp. Edge Moor boilers are installed, designed for a working pressure of 300 lb. The boilers are arranged four in each of two rows and operate normally at 250 per cent of their rated capacity. At this output three boilers sufficient to furnish steam for one 20,000-kw. turbine, leaving two spare boilers to allow for cleaning and maintenance. This number of boilers, it is estimated, will also be necessary in order to furnish steam in the future for the larger generating units which are expected to be installed in the next section built.

Steam leaving the boiler proper is passed through a Foster superheater, located in the space between the first and second gas passes of the boiler, which has a capacity to increase the temperature of 90,100 lb. of steam per hour from 411 to 611 deg. F., thus realizing a superheat of 200 deg. F.

Furnaces which serve these boilers are designed for the exclusive use of pulverized coal which is fed to the four Lopulco burners provided for each boiler by screw feeders from the pulverized fuel storage bins overhead. Air supply for combustion is drawn through spaces around the furnace lining, thus reducing the radiation and bringing the temperature of the air up to 500 deg. as it enters the furnace. The volume of the combustion space is 6.1 cu. ft. per boiler horsepower, or practically 8000 cu. ft.

The burners inject the fuel downward just inside the front wall of the furnace; the gases pass downward at the front and upward at the back of the furnace, then enter the first of the four passes of the boiler. Along the bottom of the furnaces are water grates which cool the lower part of the furnaces and prevent the formation of slag. The water circulated through these coils is used for boiler feeding so that no heat is lost by this arrangement.

Flue gas analyses which are graphically recorded by instruments show average results of about 14½ per cent CO_2 and with the boiler generating at 235 per cent rating the temperature of the flue gas leaving the boiler is around 490 deg. and leaving the economizer about 210 deg., the operating steam pressure being 265 lb. and the superheat 200 deg.

It has been reported that under test conditions an efficiency of 85.6 per cent has been obtained from the boiler alone and considering boiler and economizer 90.2 per cent efficiency has been obtained. Steam used by the auxiliaries, however, was not taken account of in making these calculations.

For each boiler a Sturtevant economizer of 7603 sq. ft. of heating surface is installed, so arranged that the gases may be bypassed to the stack. Each economizer is equipped with an induced draft fan driven by a steam turbine. Water entering the economizer has a temperature of 140 deg. which is raised to 255 deg. upon leaving for the boiler.

Flues leading from the boilers to the stacks are in the form of concrete boxes approximately 8 ft. high

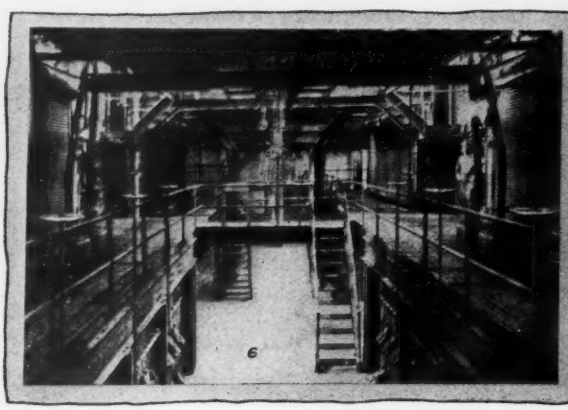


FIG. 6. OPERATING GALLERIES IN CENTER AISLE, BOILER ROOM

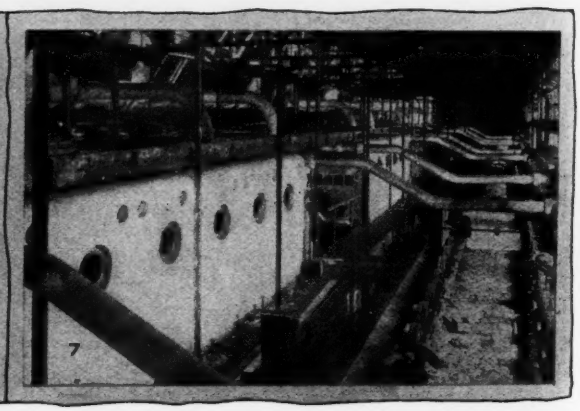


FIG. 7. REAR VIEW OF BOILERS AND FUEL ECONOMIZERS

and 11 to 18 ft. wide. These are beneath the economizers and discharge into the reinforced concrete stacks of which two are installed at the present time, each serving four boilers. The stacks stand 220 ft. above their foundations; the inside diameter at the top is 15 ft. and at the bottom 16 ft. 6 in. A 4-in. concrete lining extends to a height of 60 ft. and the main shell of the stack is 5 in. thick at the top and 24 in. thick at the bottom.

Feed water consists principally of the returns from the condensers serving the two main generating units. These returns are pumped to an overhead hot well tank, the water from which feeds by gravity to two Hoppes heaters maintaining a fairly constant pressure on the

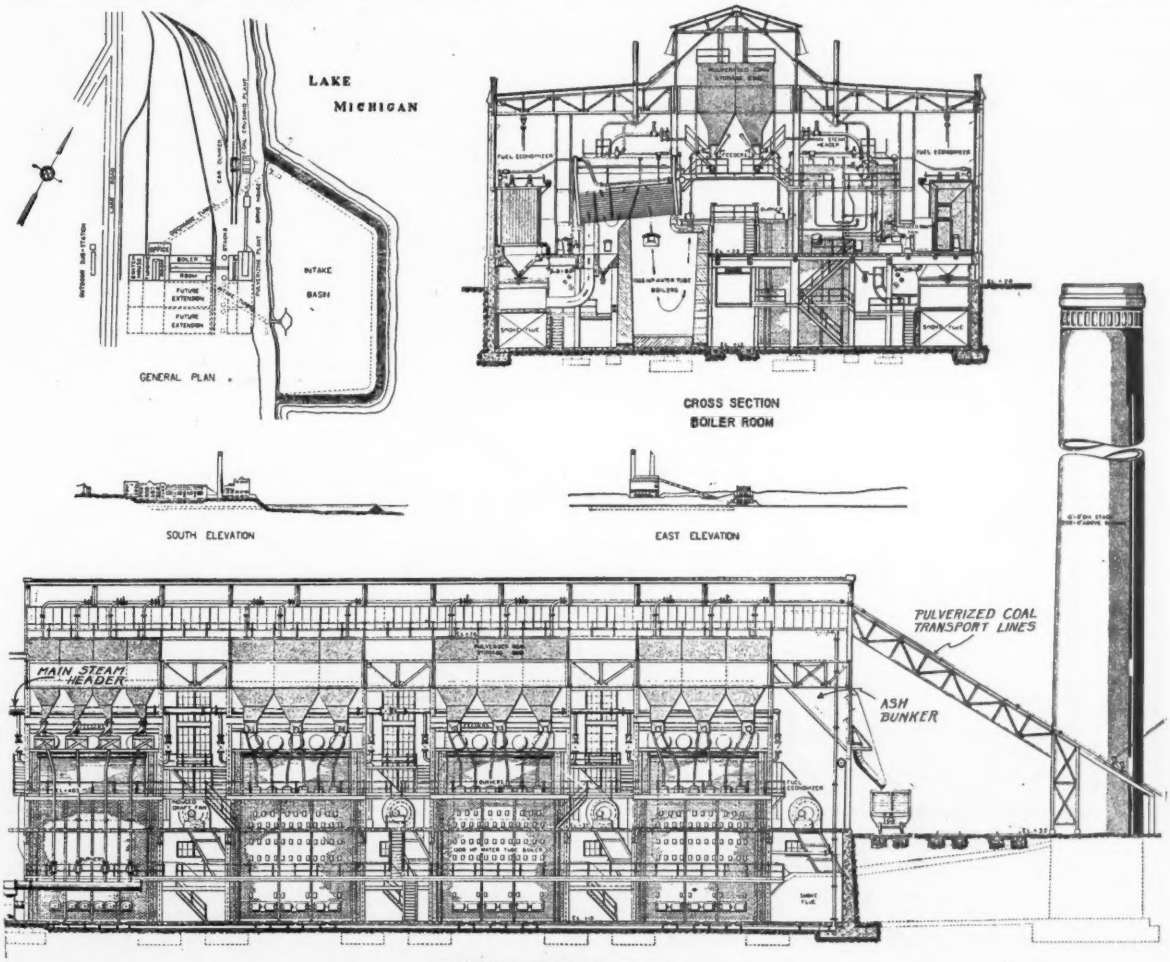


FIG. 8. SECTION THROUGH BOILER ROOM AND LOCATION DETAILS

supply pipe thereto. The heaters raise the temperature of the feed water from approximately 80 to 140 deg. F. The overhead hot well tank is equipped with an overflow to a reserve feed water basin located below the basement floor of the boiler room. The water is reclaimed from this basin by means of centrifugal pumps and is delivered to the overhead hot well tank as needed.

Leaving the heaters, the feed water flows by gravity through an 800,000 lb. per hour Lea V-notch feed water meter of extra storage capacity. Being located on the floor above the feed pumps, this meter gives a suction head on the pumps of about 15 ft.

There is also installed a common test line with connections from condensate pumps on each condenser which discharges into a test meter of the V-notch type of 300,000 lb. per hour capacity, from which it flows by gravity into the heaters. The test meter is located on a level above the overhead hot well tank.

The present installation of boiler feed pumps consists of two 6-in. centrifugal, 650 g.p.m. driven by 250-hp. steam turbines and two 4-in. centrifugal, 400 g.p.m. driven by 150-hp. motors. The maximum quantity of feed water required for the eight boilers operating at 250 per cent rating is 1450 g.p.m. This leaves two motor driven pumps or one turbine driven pump as spares. All of these pumps are of Lea Courtenay manufacture and are located at the west end of the boiler operating floor level.

The character of the ash accumulation is such that it is easily removed by a steam jet conveyor, a system of which is installed in this plant with main runs leading to furnace ash pits and branches to combustion chamber at rear of boilers and soot pits under economizers. This system delivers to an ash bunker which discharges into cars on tracks at the east end of the boiler room.

Turbine Room

In the initial section of the Lakeside station the

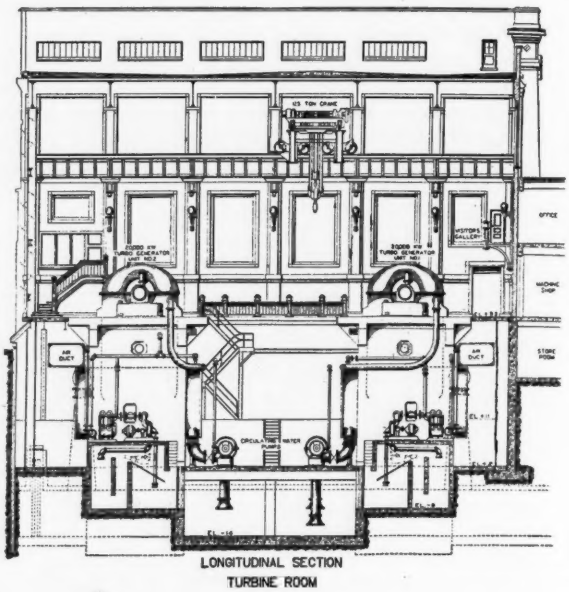
main generating units consist of two General Electric Co.'s 20,000-kw. turbo-generators delivering 3-phase current at 13,200 v. and 60 cycles, operating at 250 lb. steam pressure, 200 deg. superheat with 1-in. absolute back pressure.

Serving each generating unit is a three-pass surface condenser of 35,000 sq. ft. condensing area, with which is provided two 24-in., 18,000-g.p.m. circulating water pumps, one being driven by a 170-hp. motor the other by a 170-hp. steam turbine. The condensate pump is driven by a 50-hp. motor and the turbo air pump by a 100-hp. motor. A steam jet air pump is also provided. All of this condensing equipment was furnished by the Wheeler Condensing & Engineering Co.

It will be noted that each condenser is provided with two half capacity circulating water pumps, both of which will be required during the summer months when the water is warm but only one will operate during the cooler months.

Because of the great amount of water, 360,000 g.p.m. or 518,000,000 gal. in 24 hr. which will be required for condensing purposes when the ultimate capacity, 200,000 kw., is reached, the problem of furnishing this water to the plant at the least expense for pumping was one of the most difficult met in the design of the plant. In order to secure this supply from the lake without going out into deep water, it was decided to build a rubble mound enclosure extending approximately 485 ft. out from the shore and approximately 850 ft. long, to provide in effect, a pond of still and clean water for this purpose. It is the function of the rubble mound to break the force of the waves, and prevent rubbish, sand and ice from washing into the intake, thus permitting the intake tunnel to be terminated near the shore line. The discharge tunnel is arranged to discharge either inside or outside the basin, so that in the winter time, the warm discharge water can be used to prevent the basin from freezing.

The intake tunnel, which has its top 5 ft. below the water level, is terminated about 50 ft. beyond the shore line at the lake shore and a channel was dredged out 15 ft. deep leading up to the tunnel. This tunnel is protected at the lake end by a timber ice boom, a submerged sheet pile weir having its top 5 ft. below the surface, and a steel bar screen with 6-in. spacing. Inside the plant, the circulating water passes through two Chain Belt Co. revolving screens having ½-in. mesh, into a large suction chamber between the foundations of tur-



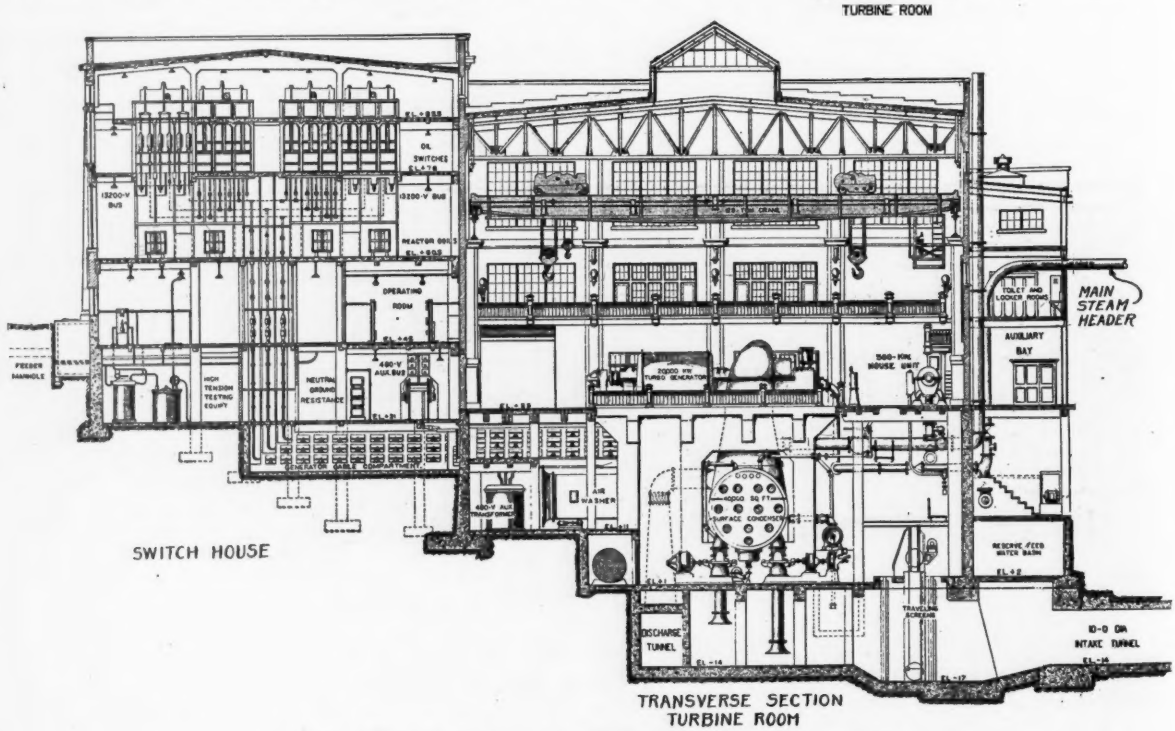


FIG. 9. SECTIONS THROUGH TURBINE ROOM AND SWITCHHOUSE

bines Nos. 1 and 2. Gate houses are provided at the lake ends of both intake and discharge tunnels so that stop logs can be placed for shutting off the water at these points.

Over 1100 lineal feet of tunnel and 150 ft. of construction shaft were required for the circulating system, together with gate houses and a large screen and intake chamber below the condensers and pumps in the turbine room. The tunnels have 10 ft. diameter inside and are lined with a concrete wall having an average thickness of 18 in.

Clean washed air is supplied for cooling the generator by means of a Carrier air washer provided for each generator which draws its supply of air from the main turbine room, thereby eliminating separate screen house and air duct to outside of building. During cold weather air is admitted to the turbine room from the outside through the monitors in the roof while during the milder weather it is admitted through the ventilators in the windows. Air warmed in the generators is discharged into the basement of the boiler room through sheet metal ducts, thereby using the heated air to augment the regular supply to the boiler furnaces. Provision was made in these discharge ducts to bypass enough air back into the turbine room during cold weather to keep the temperature comfortable for the workmen without additional heat.

Automatic dampers have been installed in both intake and discharge ducts as close to the generator as possible as a means of fire protection. These close automatically when an unusually high temperature is obtained such as might be occasioned by fire. Arrangements have also been made for admitting high pressure steam to the generators for fire extinguishing.

Pumps for sanitary service have been provided and are so connected as to be available for boiler feed tank service. An air compressor for cleaning generators and other electrical equipment, operating pneumatic tools, boiler tube cleaners and general service forms part of the station equipment.

In order to obtain a well balanced heat condition for use in connection with heating feed water to a suitable and regular temperature before introducing it to the economizer, steam driven boiler feed pumps, induced draft fans, and half of circulating pump capacity were installed leaving the balance of steam required for heating feed water to be supplied in varying quantities by the house unit, or so-called heat balancer. All other auxiliaries are direct motor driven.

The economy of the station when completed and operated at full load factor will be that which will result from a combined boiler, furnace, superheater, and economizer efficiency of 88.15 per cent using Illinois coal of approximately 11,000 B.t.u. heat value as received.

It is planned that the ultimate development of the plant will reach a running capacity of 160,000 kw. with an installed capacity of 200,000 kw.; 40,000 kw. being

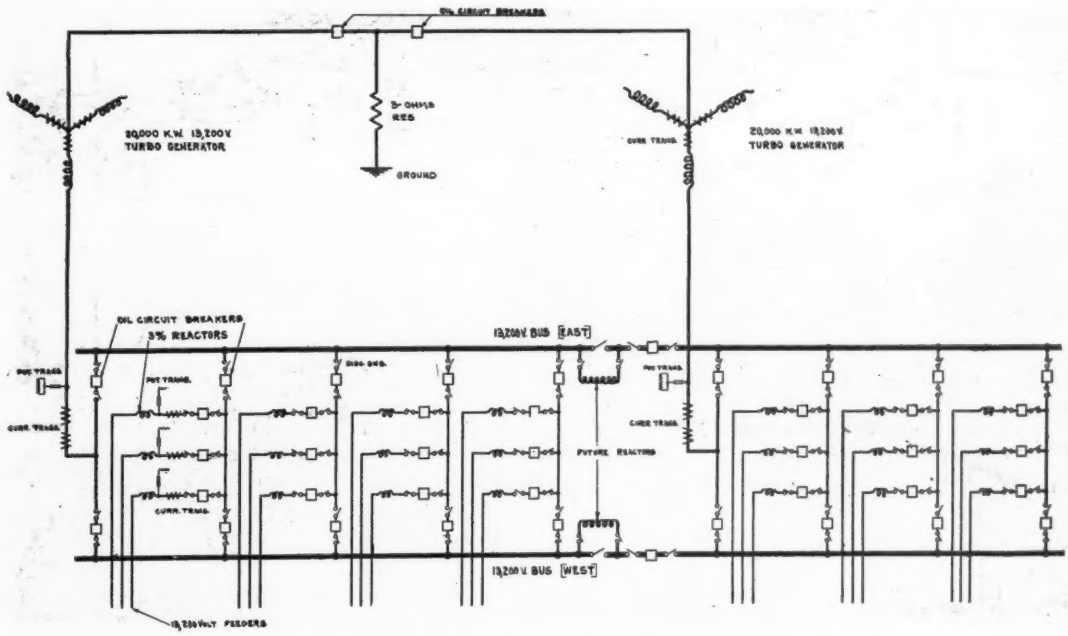


FIG. 10. SINGLE LINE DIAGRAM OF ELECTRICAL CONNECTIONS

the initial installation and two additional sections, one of which is now under construction, of 80,000 kw. each as a future plan. The plant will be laid out for generation of 60 cycle energy only and will expand in the southerly direction. The final total boiler capacity will be three times that of the initial installation and will comprise twenty-four 1306-hp. boilers. All 24 boilers operating at slightly over 200 per cent rating will supply steam for 160,000 kw. of generator capacity and when operating at 250 per cent rating will develop the maximum installed generating capacity of 200,000 kw.

The economical results so far obtained indicate that there will be no difficulty in reaching the specified thermal efficiency of the station when the installation is complete and the station operated as specified.

The design work of the steam and mechanical section of the plant was done entirely by the company's engi-

neers with such co-operation from Combustion Engineering Corporation engineers as was necessary to obtain the best results in the boiler room.

Electrical Features

The electrical equipment at the Lakeside plant was selected and arranged so as to secure maximum reliability of service and freedom from complexity. The electrical equipment of any plant is at best somewhat complicated and in order that it may be operated and maintained properly it must be installed in such a way as to make all equipment easily accessible for inspection and repairs. It must be arranged as simply as possible so as to reduce to a minimum the liability of confusion on the part of the switchboard operators. Not only must the equipment be installed to prevent trouble, but also to prevent it from spreading when trouble does occur. These principles were kept in mind in the electrical design of this plant and their application will be pointed out in the description which follows.

Current is generated at 13,200 v., 3-phase, 60 cycles, and leaves the station through underground cables without being transformed. A number of these underground lines rise a short distance from the plant to feed overhead lines. Where current is to be transmitted to distances exceeding six miles the voltage is stepped up to 26,400 v. at an outdoor transformer station, located on the west side of the state concrete road. Future developments or expansion may require that the voltage be stepped up to 66,000 v. for transmission to remote points.

Under normal conditions each generator is furnished with excitation at 240 v. by its own direct connected exciter. Engineering excitation is furnished from the direct current station power service. While some of the station power service is supplied at 240 v. direct current most of it is supplied at 480 v. 3-phase, 60 cycles, alternating current. Station lighting is supplied from a 120-240 v. 3-wire system supplied from transformers connected to the 480 v. station power system. Certain lighting units throughout the building, however, are permanently connected to the 240 v. station power system, which is equipped with a storage battery so that sufficient lighting for operation is assured in case of emergencies.

The control circuit for the high voltage oil switches is supplied with 120 v. direct current from the storage battery and from special motor generator sets. If necessary, the oil switch control may be transferred to the battery on the direct current station power system by connecting it across one-half of cells.

Generators

Two 20,000 kw., 80 per cent power factor, 3-phase, 13,200 v. 60 cycle General Electric Co. generators are installed in the initial unit of the plant. These machines operate at 1800 r.p.m. As stated previously, the exciters are direct connected to the generators and are of 110 kw. capacity. In case the regular exciters fail, arrangements have been made on the field control panels to cut off the disabled machine automatically and to cut in emergency excitation from the 240 v. d.c. station power supply. To protect the generators from serious internal injury due to insulation breakdowns and prevent such trouble from too greatly affecting the system, measures have been taken to cut the generators off automatically if trouble within the machine occurs. To accomplish this, both ends of each phase winding are brought out to the terminal boards, thereby permitting the installation of current transformers in the neutral connections. These current transformers, together with others installed in the main generator leads, are connected to relays which will operate in the event of trouble in the generator windings and kick open the main generator and field circuit breakers. Under normal operating conditions the current circulates through the current transformer secondaries and the wires between them and none passes through the relays. Trouble anywhere in the generator windings cause one current trans-

FIG. 11. GENERAL VIEW OF OPERATING ROOM

former to carry more current than the others, the unbalanced current passing through the relays and operating the breakers. Generator neutrals are connected to ground through a 3-ohm resistance in order to limit the current to ground in case of line trouble and thereby reduce the severity of such trouble.

High Tension Equipment

The 13,200-v. main connections and circuit breakers, located exclusively in the switch house, except for the generator leads where they leave the generators, are shown schematically in Fig. 10. It will be noted that there are two main bus bars with sectionalizing switches between generator sections. To promote safety and prevent electrical trouble from spreading, all high tension copper and cables are taped with approximately ¼ in. of varnished cambric and covered with a layer of cotton tape impregnated with a fire resisting substance. Each generator may be connected to either main bus through oil circuit breakers. Feeders are connected in groups of three to feeder group bus bars, which in turn may be connected to the main bus bars through group oil circuit breakers.

The actual arrangement of equipment in the switch house conforms almost exactly with the schematic diagram. The main circuit breakers of different generators are separated a considerable distance from one another with from three to four groups of feeder breakers between them. Because of this it will be difficult for trouble on one set of generator breakers to be communicated to the breakers of other generators. The group breakers of any one feeder group are located as far as possible from one another, one being at one end and the other at the opposite end of the feeder section. This makes it unlikely that trouble in one group breaker will involve the other group breaker on the same feeder group.

The oil circuit breakers are located on the third floor while the operating mechanism is installed on the floor above. The main bus bars, potential transformers, feeder current transformers, feeder reactors and feeder group bus bars are on the second floor, while generator current transformers, feeder lightning arresters, feeder potheads and disconnecting switches are on the first floor. The generator leads pass in a nearly horizontal direction from the generator foundation through a tunnel underneath the switch house and then rise vertically to the generator selector bus on the second floor. The generator leads each consist of two 1,000,000 c.m. single conductor, stranded copper cables insulated with 7/16-inch cambric and covered with a flame proof braid. The main generator oil circuit breakers are General Electric type H-6, rated at 2000 amp., 15,000 v. and are capable of rupturing 18,000 amp. at the rated voltage. Each pole of these breakers is located in an entirely separate compartment and the crossheads are in another separate compartment underneath the operating mechanism on the fourth floor. The main bus bars on either side of the room consist of two or more ¼ by 4-in. copper bars, as required, suspended from the ceiling on substantial porcelain insulators and are separated from one another by gypsum barriers 2 in. thick. The main bus bars, it will be noted, are on opposite sides of the room making it practically impossible for trouble on one set of bus bars to involve the other.

Each feeder group bus is connected between group oil circuit breakers, one of which is directly over the east main bus. Feeders are tapped off, as shown in Fig. 10, between the group breakers. Conductors run from the feeder bus through porcelain bushings in the wall, thence upward to the feeder oil circuit breakers and down through current transformers and feeder reactors to disconnecting switches and cable terminals. Group oil circuit breakers are General Electric type H-6, rated 800 amp. 15,000 v. with a rupturing capacity of 18,000 amp, at rated voltage. The crossheads, as in the case of the generator breakers, are located in a separate compartment underneath the operating mechanisms on the fourth floor. Feeder breakers are General Electric type H-3, rated 300 and 500 amp., depending upon the size of feeders connected and will rupture 10,000 amp. at 15,000 v.

There are two sizes of feeder reactors, for 500 and 200-amp. feeders, respectively. In each case the voltage drop across a reactor is 3 per cent of the voltage from phase wire to neutral when it is carrying its rated current.

Station Power Service

Station power service is furnished by two separate systems, a 480-v. alternating current system fed from transformers and a 240-120-v. direct current system fed by motor generators. The 480-v. alternating current system was selected because a number of the motors such as those used in connection with the coal crushing and pulverizing equipment are located at a considerable distance from the source of supply. It was further decided that some direct current auxiliary service should be furnished on account of the turbine room crane, motor operated steam valves, car dumper, magnetic pulley and certain operations requiring variable speed. To make this service available as an emergency source of excitation, 240 v. was selected.

Service for alternating current auxiliaries is furnished by two 3000-kv.a., 13,800-13,200/480-v. 60-cycle, 3 phase, water cooled transformers, one serving as a reserve for the other. These transformers are located in the turbine room basement underneath the mezzanine floor on which the generator field and exciter rheostats, neutral oil circuit breakers, and other electrical auxiliaries are located. Located as they are, the 13,200-v. cables supplying them are short and do not pass through any part of the plant where they may be subjected to too much heat and consequent liability of trouble. Bus bars, transformer circuit breakers, and oil circuit breakers on feeders to distribution points throughout the plant are all in duplicate. There is one main feeder to each main division of the plant, such as pulverizing building, coal crushing house, boiler room, turbine room and switch house. In addition there is an emergency feeder to each of these points to be used in case of trouble on the main feeders. Large air break circuit breakers are used instead of oil circuit breakers on the secondary side of the auxiliary transformers. These breakers are provided with reverse power relays so that with both transformers in operation, trouble in a transformer or on its primary feeder will cause the proper breakers to open, thereby clearing the trouble without interfering with the service. Station distribution switchboards, located in various parts of the plant, are con-

structed in such a manner as to make it possible to kill half of the system for work to be done without interfering with service on the other half.

The general arrangement of the direct current auxiliary supply is similar to that of the alternating current. This system is supplied by two 300 kw. motor generator sets, one serving as reserve for the other and each consisting of a 480-v. 60-cycle, squirrel cage induction motor, direct connected to a 250-v. direct current 1200 r.p.m. shunt wound generator. These sets are supplied from the 480-v. alternating station power system. To guard against a shut down a 150 cell G-15 battery in G-23 tanks is kept floating across the 240-v. direct current bus. The main direct current bus bars and switches are located on a switchboard in the operating room. Each main feeder is provided with an ITE circuit breaker and at the various distribution panels and cabinets in the plant, fuses are provided on branch circuits.

Station Lighting

The greater part of the station lighting is supplied from the 480-v. alternating current power system through transformers stepping down from 480 to 120-240 v. for 3 wire distribution. Certain circuits, however,

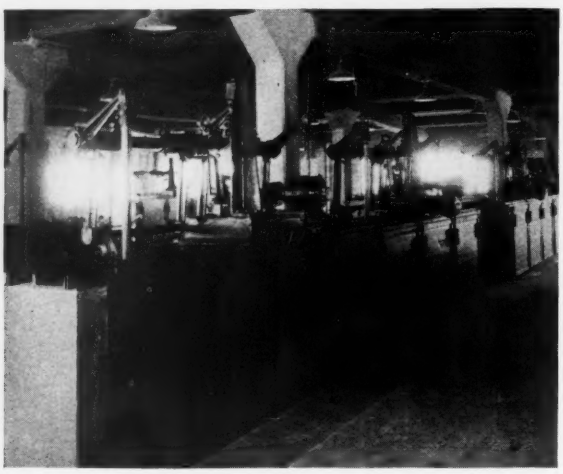


FIG. 12. VIEW OF SECTIONALIZING AND GENERATOR OIL CIRCUIT BREAKER MECHANISMS

in vital portions of the plant have lamps connected two in series to the 240 v. direct current station power system which cannot fail because of the battery. Other circuits, in some cases, may be thrown to the direct current system, if necessary. The lighting system is entirely independent of the power circuits, the main distribution being from a switchboard in the basement of the switch house. Steel enameled fixtures are used in most parts of the plant. In the turbine room it was desired to have the entire room illuminated as well as possible without resorting to side bracket or local lighting. Tight light fixtures with holophane bowl refractors directing the light downward at an angle of 30 deg. below the horizontal, were installed. These fixtures are about in the plane of the bottom members of the roof trusses. Nine of these units equipped with 500-watt lamps are required in the present installation. The full effect of this system of illumination will not be realized until the proposed additions to the plant have been made, making the turbine room an ordinary city block in length.

The problem in the operating room was adequately to illuminate the vertical sides of switchboards where the instruments and switches are located and at the same time the rear of panels. In the arrangement used the fronts of the boards are illuminated directly from the units whereas the rear of switchboards are illuminated by reflection from the walls.

Operating Switchboard and Control Wiring

A general view of the main operating room is shown in Fig. 11, looking south. The direct current station power service control board is shown in the right foreground with the 13,200-v. feeder board beyond it. The alternating station power service control board is shown in the left foreground with the generator bench board beyond. As the station grows the temporary wall in the background will be removed to permit the unlimited extension of the switchboard in that direction.

The swinging panel contains the synchroscope, direct current voltmeter for exciter and frequency indicators. The bench sections contain control switches for generator, sectionalizing and group oil circuit breakers and field and neutral switches, voltmeter receptacles, synchronizing receptacles, main field and exciter field rheostat switches, bell alarm relay, temperature switch and receptacles and signalling equipment.

The main station wiring is represented by mimic busbars on the bench sections and the arrangement of control switches is such as to conform exactly with the arrangement of oil circuit breakers and busbars in the plant. The generator oil circuit breakers are wired in such a way that they cannot be closed without the synchronizing plug being in its receptacle. The same is true of feeder oil circuit breakers.

At one end of the direct current auxiliary switchboard are two panels for the control of oil switch control circuits. One of these is for the control battery, which consists of 60 Navy Exide cells in 15—4-cell trays. Two 15 kw. motor generator sets supply the energy for the control system. The other panel is for the control of individual control circuits. A feature of this system is that the control circuits to different parts of the operating switchboard are supplied through separate switches so as to facilitate the location of control circuit trouble.

On the west side of the Lake road, opposite the switch house, there is an outdoor step-up transformer station, which in the initial installation contains four 10,000 kv.a., 3 phase transformers stepping up from 13,200 v. to 26,400 v. for transmission to points generally in excess of six miles from the station. Each transformer will be connected in a 10,000 kv.a. line and will virtually be a part of the line. In the event of trouble on the line the automatic breaker located in the switch house on the 13,200-v. side of the transformer will open.

The information forming the basis of the description of this plant is taken from the first public statement on the construction and equipment made by the company in the form of papers presented before the Technical League of the Employes' Mutual Benefit Association by R. H. Pinkley, engineer of way and structures, John Anderson, chief engineer of power plants and G. G. Post, electrical engineer, all of the Milwaukee Electric Railway & Light Co.

Hogged Fuel*

ITS HEAT-PRODUCING VALUE; DESIGN AND ADAPTABILITY OF THE FURNACE; MEANS AND METHOD OF HANDLING THE FUEL TO THE FURNACE GRATES. BY EMERY A. MORRISON

TO ACCOMPLISH satisfactory results in the use of a fuel the user must be somewhat informed in the theory or technics of combustion, and then make practical arrangements so that the theory and practice may be accomplished, not only by the one setting it up, but by the average man, such as we are dependent upon to perform all the duties of a boiler-room attendant.

In the development of hogged fuel uses, we become interested in three phases of an engineering problem; first, the heat producing value of the fuel or mill refuse as we receive it; second, the design and adaptability of the furnace; and third, the means and methods of handling the fuel to the furnace grates, to the end that we may get satisfactory combustion and results. We must not lose sight of the fact that the results obtained are a result of properly co-ordinating all three factors toward one common end.

Realizing that hogged fuel is valued as a heat-producing commodity, we are interested in its product—heat. In hogged fuel, as in coal, we find the combustible or combining elements, carbon and hydrogen. Western woods, when dry, consist of about 50 per cent carbon and 6 per cent hydrogen. These elements under the influence of kindling temperatures have a great affinity for another element, that of oxygen, of which air is about 21 per cent and the combination of which sets up a molecular activity resulting in the heat developed in a furnace. In the problem of manufacturing heat from the combustible matter in hogged fuel, or bringing about to their proper form the combustible elements of the fuel and required oxygen from the air, we have to deal first with the fuel as we receive it, and the question is asked, "What is the value of hogged fuel per unit of measurement?"

Up to the present time, most of the mill refuse is bought by the consumer on the basis of say 200 cu. ft., representing a volumetric unit, and paid for on that basis regardless of the actual quantity of the combustible available for heat production, or the quantity of moisture in it, which requires a portion of the total combustible to remove it, thus depreciating the value of the fuel more or less. We all appreciate that there is a difference in hogged fuel, but are lacking in a standard way of determining the extent of the difference.

At the boiler plant of the Consumers Central Heating Co., of Tacoma, 26,000 volumetric units of 200 cu. ft. were used during the year 1921. During the colder months of the year when our fuel requirements were greatest, we received a better grade of fuel than during the summer months. In this we found our fuel costs to vary, which from the cash register end of the concern promoted an investigation of the extent of the difference in values. Equipment consisting of several square cans of 2 cu. ft. capacity each, or the 1/100 part of a volumetric unit, and a small counter scale were furnished. A small sample was taken from each unit as it was unloaded, until out of each 20 units a 2-cu. ft. sample was gathered which we considered as representing the average of the 20 units. Thus the average weight of the unit was determined.

These samples were set out on the hot furnace top to dry; after being dried, the sample was again weighed and the percentage of free moisture determined. Thus for several months the sampling process went on, covering several thousand units, during which time hourly evaporation readings were taken and comparisons made. In all we found clear fir hogged fuel to be the most valuable. The average weight of some 1200 units was 4003 lb. The average per cent of free moisture was 38.3, the evaporation value swinging from 8000 to 12,000 lb. of water. For making comparisons, the speaker took the privilege of setting up a standard unit to weigh 4000 lb. and contain 38 per cent of free moisture, and for making still further comparison, assumed that unit

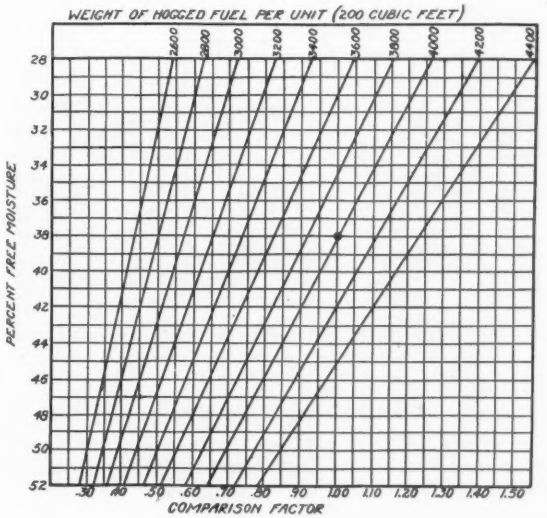


FIG. 1. COMPARATIVE VALUE OF FUELS OF DIFFERENT WEIGHTS AND MOISTURE CONTENT AS TO THAT OF FUEL WEIGHING 4000 LB. PER UNIT OF 200 CU. FT. BEARING 38 PER CENT MOISTURE

should under normal operating conditions evaporate 10,000 lb. of water, its base value being 1.00.

In comparing fuel of less weight, it was at first assumed that the evaporation value would drop directly in proportion as the weight of combustible dropped, first making corrections for the difference in moisture content and the combustible required to relieve the moisture, deducting for excess moisture and giving credit for less moisture than that set up on the standard unit basis. We found our evaporation much less, however, with the lighter fuels, and after consideration, realized that in the modern furnace designed to burn the average grade of fuel, with fuels of a lighter nature the full allotted furnace space would be taken up in bulk, but with less actual combustible, and realized that to meet the demand of a commercial heating load the lighter fuel must be reduced from a physical substance to that of energy and ash in less time, and the increased rate of

*From a paper read before the Western Section of the American Society of Mechanical Engineers.

combustion associated with other features accompanying it caused the burning efficiency to drop directly proportionately as the weight of the light fuel departed from that of the standard unit.

A record has been kept based on the mentioned fuel value determining method and actual evaporation results for the last three months of 1921, during which time we consumed 7096 units of an evaporation value of 8721 lb. per unit, and actually obtained 8717 lb. per unit, being about one-half of one per cent below that determined. I do not, however, mean to state that the figures given are set values on the fuels of different weight, but are what I believe to be a comparative value of fuels that may serve as an aid to the seller and buyer

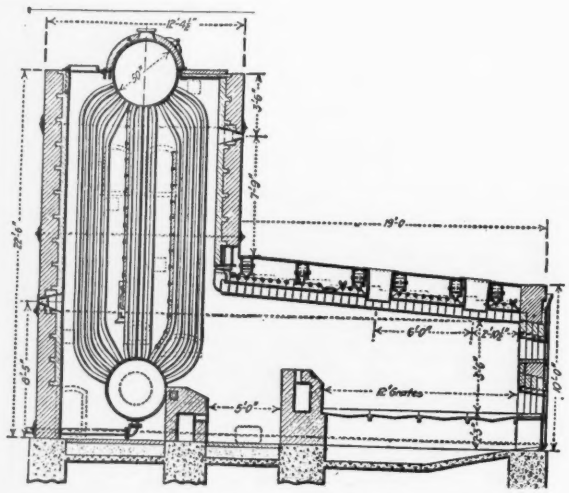


FIG. 2. DUTCH OVEN TYPE FURNACE OF MODERN DESIGN FOR BURNING HOGGED FUEL

in the way of determining what a particular fuel may be worth if properly used. It is quite possible with better load conditions than our plant enjoys to bring the average evaporation of the standard up, and so in proportion the lighter fuels.

Considering Furnace Design

From the old sprung arch dutch oven has been developed one of the later type furnaces (Fig. 2) of which three were designed and constructed for the Consumers Central Heating Co., Tacoma, Wash., by M. R. L. Watts, of Lewis & Watts. These furnaces each serve in front of a 750-hp. Erie City boiler. This roomy furnace has 216 sq. ft. of grate area, the grates being 12 ft. long by 18 ft. wide. The fuel is fed through four water-cooled thimbles and has dampered excess air ports in the first bridge wall, and over-draft dampers in the fronts. Under favorable conditions and with good fuel, the combination is capable of developing 200 per cent rating.

Figure 3 shows a furnace that is in operation at the steam plant of the North Coast Power Co. and is unique in two particular features, namely the drooping arch and shaker grate. I believe the drooping arch aids in combustion of the fuel, first in that heat radiated back on the fuel bed drives off the moisture and volatile gases in the presence of less excess air than would be accomplished normally, also it tends to break up the stratification in the flow of rich and lean gases and being in this position it would also aid in that it would rarely be possible for combustible gases to pass, wanting for ignition temperatures. The shaker grates would facilitate greatly in cleaning.

In Fig. 4 the writer presents a design of furnace embodying the features of advantage from most of the foregoing, and adding to them as experience would suggest from the stoker furnace development, remembering that in the design we must endeavor to deal with theoretical and practical completeness as much as possible, leaving as little as we can to the responsibility of the man actually charged with its operation—the boiler room attendant.

You will note that this also embodies the sloping grate feature, going a little further in that direction; the elevated boiler heating surfaces to gain a little longer gas travel and acquire the ignition or reflecting bridge wall, also a slightly drooping suspended arch, which, due to the angle of deflection, it would seem, might change the course of the gas flow to break up stratification of the gases sufficiently and also aid in ignition if need be. I would suggest a water-cooled feed thimble be suspended to about 6 or 8 in. below the heated surface of the arch, the fuel to feed through these thimbles by a boxed-in chute or hopper from which the fuel would settle gently to the fuel bed as the requirements demanded.

A regular fuel conveyor with slide openings could be placed over the top of this feed chute and left wide open, the refilling of the chute taking place automatically as the fuel in the chute lowered towards the grate. A contrivance of this nature, carefully designed, should entirely eliminate all byways for the admission of unnecessary air overcoming in general the same difficulties

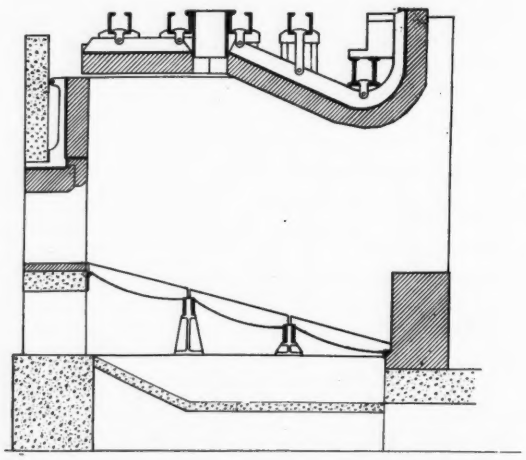


FIG. 3. FURNACE WITH DROOPING ARCH

as the stoker overcame in its change from the hand-fired furnace. The fuel bed should then be maintained at a desired depth, this depth to be determined by the designer or may be made changeable by means of lowering or raising the thimble. With the use of the shaker grate a dead fire may be agitated and brightened up or the grates easily cleaned.

Of the excess air feature, let me say that its unwelcomed presence not only uses heat already developed in

the furnace to raise it from room temperature to that of the stack temperature, but it increases the volume of gases, and being thus increased, all the gases must flow at a greater rapidity over the boiler heating surfaces, thereby making all the heat in the total gases not quite as available for the water in the boiler as would hotter gas moving at lower velocity. The fact that its presence also lowers the temperature of the deflecting arches, etc., gives it an opportunity to carry on with its just mentioned habits, incomplete combustion due to poor ignition, all this with an abnormal increase in the rate of combustion.

Suggestions Brought Out in Discussion

Previous to considering the development of the combustion space of a furnace, it is of importance to arrange a more consistent method of converting the heat products of the fuel used into as fine a quantity as possible over the grate, to the end that we do not find ourselves manufacturing a very crude product there, and building up the combustion space of the furnace to be loaded with the burden of correcting the mistakes of a poorly designed grate and front end of the furnace, remembering that of the combustibles in fuel there are two distinct elements or combination of elements, i. e., fixed carbon and the hydrocarbons. Of the two, each requires a distinctly different combination of circumstances, of which time, temperatures and draft, or the presence of free oxygen are the factors.

The hydrocarbons or volatile gases develop more normally by coming gradually into rising temperatures, the moisture and lightest elements precipitating first, and in turn until the fixed carbon develops more normally in absences of the molesting features of the lighter combustibles and moisture. If constant temperature is given, a proper opportunity to work out its share of aid to combustion, more especially with that of green wood, less responsibility is required of the combustion space. However, without the facilities to gain the proper developments on the grates, a properly designed combustion space is a valuable heat redeeming feature and should not be overlooked. In the opinion of the writer, with such types of boilers as will conveniently permit, the extensive combustion chamber should be taken advantage of, but do not think it advisable to go too far in this direction, especially outwardly from the heating surface of the boiler.

Quite frequently bolts, hand tools, and broken parts of mill machinery come through with the fuel. In most, these parts accumulate from the repair work about the mills where the sawdust conveyors deposit on the same conveyors as does the hog. For this as well as other reasons, a moving grate or stoker would be extremely difficult to develop.

Where sea water soaked logs are cut and the hogged fuel used, a fine coating of salt covers the heating surfaces, but if occasionally cleaned, no destructive results occur.

The kind of grates to be used in a hogged fuel furnace depends entirely on the combination of circumstances that are involved. If fixed grates are used and the fuel used is quite free from sand or earthy substances that may accumulate on the surfaces of the logs while in transit from the forest to the saw, the two finger grates seem to give fair satisfaction; however, when first put in place, the openings are usually too large, allowing a considerable amount of charred wood or combustible to fall through into the ashpit, and if allowed to burn there would ruin the grates. In this event, the ashpit should be kept flooded and cleaned out until by the formation of clinkers on them, the openings become partly closed. For the average run of green fuel, the writer would suggest that the grate design be proportioned to develop 250 per cent boiler rating with one square foot of grate area for each 42 sq. ft. of boiler heating surface, and that not less than 30 per cent of the great area be open at all times for free passage of air through them to the fuel bed.

At the plant of the Consumers Central Heating Co., with the use of fuel that is free from sand, sea shells, etc., is is not necessary to clean the grates until about 2000 lb. of fuel per sq. ft. of grate area has been consumed. About 90 per cent of the ash falls through the grates into the ashpit, the balance forming a scale or crust on the surfaces of the grates which is quite easily

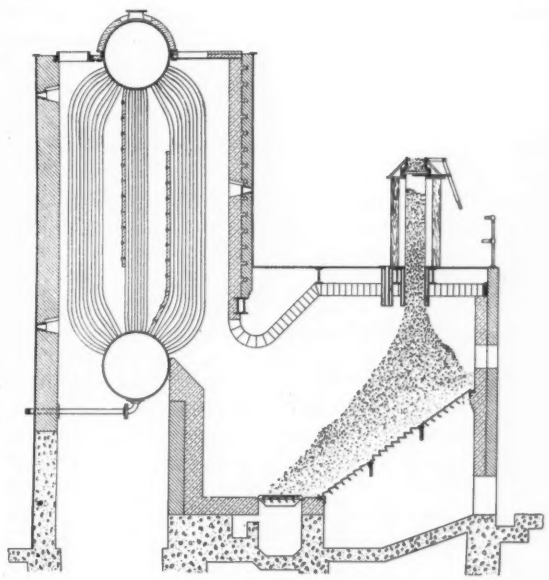


FIG. 4. SUGGESTED FURNACE DESIGN EMBODYING MODERN FEATURES

removed when done so at a proper temperature. When the fuel is first burned low, this crust formation of the ash is hot and sticky like molten lava; when partly cooled it is easily removed with an ash hoe or slice bar, but if allowed to become cool it adheres to the grates and becomes very difficult to remove.

With all western woods, it has been my experience that they compare quite favorably as to their heat-producing value when compared as to their weight per volume, first making the proper allowances for the free moisture contained and the combustible required to remove the moisture. With hemlock it has been my experience that the foregoing comparative value basis will hold good, especially if mixed with other more substantial woods.

The burning of hemlock hogged fuel alone offers a more complex situation, due to the nature of the composition of the elements in the fuel, first in the lack

of volatiles in hemlock or rather the excessive ratio of moisture to volatiles, in which case the void spaces in the wood become more thoroughly impregnated with free moisture and lacking in volatiles which act as a more suitable agent to aid in the relief of moisture than fixed carbon, due to the fact that the volatiles distill more readily and combustion takes place at lower temperatures. When attempting to relieve moisture and burn fixed carbon in a singular operation, the effect is that the excessive moisture predominates, lowering the temperatures below that properly required for good combustion of fixed carbon, and for this reason the principle of the furnace design should be to have the fuel feed gradually into rising temperatures to permit each of the elements in the fuel to develop normally at the condition most suitable to its nature.

Setting Valves by Elliptical Diagram

New Method Employed on Marine Engine When Time for Shutdown Was Limited. By Arthur O. Gates

THE ELLIPTICAL valve diagram is one in which the relative positions of valve and piston are shown by plotting the travel of each at right angles to each other, and the ellipse containing the loci of the intersections of lines drawn through these points tells the story of what is going on between the valve and piston through an entire revolution. It is the simplest form of valve diagram, and it tells the story in such simple terms that the wonder to the writer is that if it had ever been put to the purpose of valve setting previously to that described here, the facts were not published and such use had not become more general.

There is always something mysterious about the setting of the valves of an engine, getting the adjustment of lap and lead by more or less cut-and-try methods, and many are bewildered because they cannot see just what is going on either in the cylinder or the valve chest. (I am one of these.)

The common method of setting valves on marine engines after an overhauling is by the use of rods or trams which have marked upon them the positions of the valve points and the openings into the cylinder casting. One of these rods is held upon the outside of the cylinder casting, the other is set upon the end of the valve at some designated point, the engine crank for that cylinder is brought to dead center and the valve adjusted to the designated lead. It should be noted here that at this point where the valve is set, the travel of the valve is near to its highest speed while the rate of travel of the engine piston is at its slowest, or zero.

While the matter of getting the engine on dead center is not a particularly difficult problem, especially if the trams for that purpose (used at the crankshaft) have not been carried off by some enterprising workman, and are still at hand, there is always a chance for uncertainty in the measurement and adjustment of the lead as suggested in the paragraph above.

In January, 1918, the U. S. S. Marblehead was released from Mare Island Navy Yard after a short overhaul of her engines which necessitated resetting of the valves. This was done in the usual way, and it was expected that she would operate as well or better than on the long cruise to South America which had been made a couple of months previously. I believe it is always customary to cuss the yard and overhaul the main engines or any other parts which the yard worked upon as soon as possible after getting out of the yard, and in spite of all the benefits gained by the yard work, so that the work that was done was in accordance with good old navy tradition.

It was found in the run down the California coast that the engines were rather noisy, that they did not respond as well in maneuvering, and the indicator cards showed that considerably more work was done upon the top end than by the bottom end; it should have been just the opposite to take care of the weight of the reciprocating parts.

The duties of the ship kept it under way almost continually, as outside of the battleship Oregon it was at that time almost the whole of the Pacific fleet, so that it was impossible to obtain permission to disable the engines for the purpose of resetting the valves in the manner previously done. It was thought by the chief engineer and his assistant who had been with the ship previous to the overhaul that an error of 1/16 to ⅛ in. had been made in the setting of the valves and that raising the piston valves this amount would turn the trick.

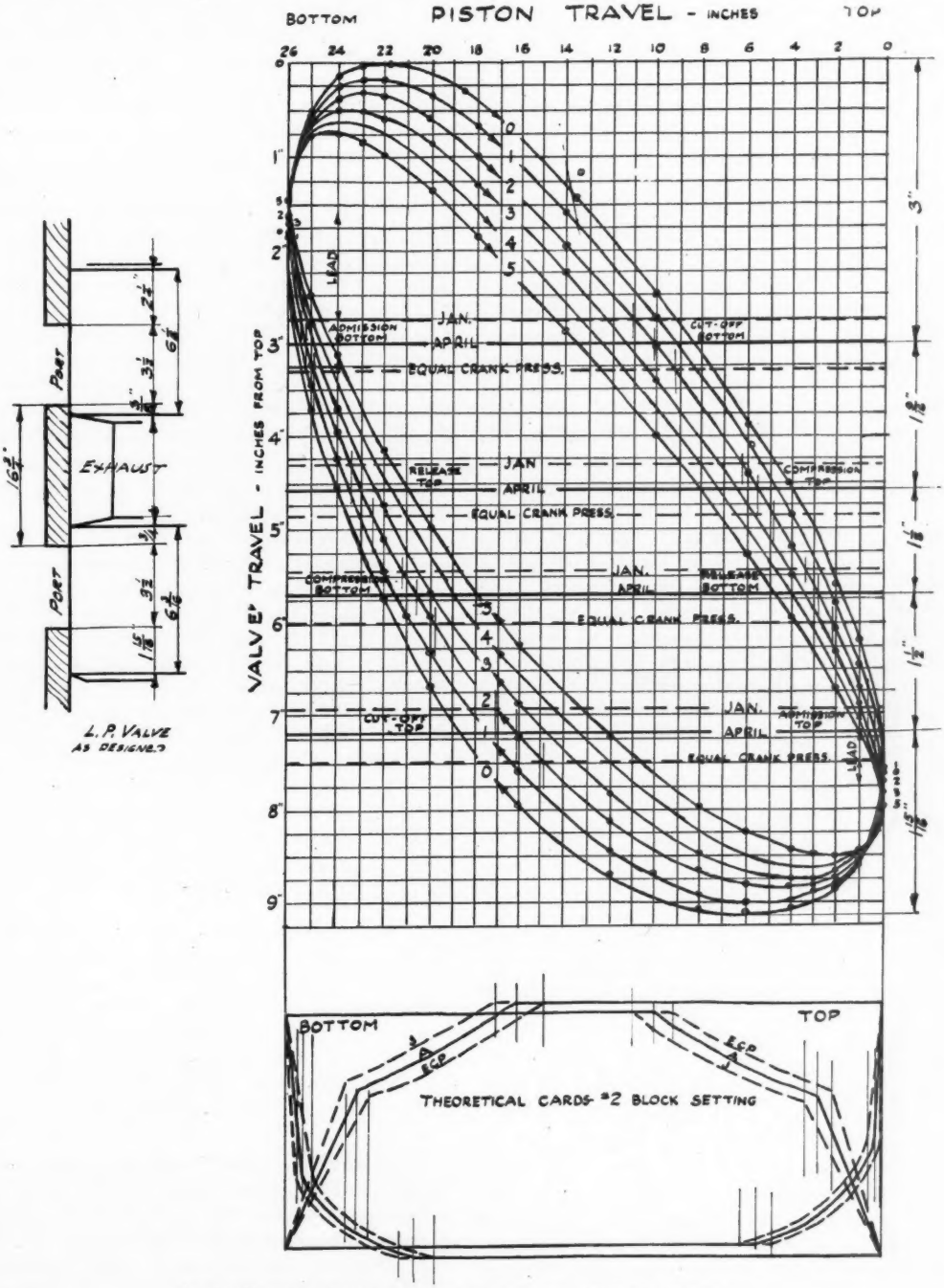
The engines of this ship were designated as having a combined rating of 5000 hp., but as changes had been made in the fire-rooms to make it a more livable ship, and as the ships built at the time the Marblehead was constructed fell notoriously below their trial performance, the engines were at least twice as large as was needed for cruising conditions, and for the maximum power it was possible to get from her boiler plant. It is evident to one familiar with the conditions that the setting of the valves determined probably for maximum speed conditions as designed would very likely not be right for conditions calling for half or a quarter the 5000 hp.; and that the valves should be set for the best she could do under present circumstances.

The writer, as assistant engineer undergoing training (whatever that was he has never been able to determine) was assigned to the duty of planning and making these changes. He had been somewhat familiar with the elliptical valve diagram and 18 yr. previously had taken such a diagram upon the U. S. S. Philadelphia in a rather crude manner by fastening a string around one of the rocker shafts of the Marshall valve mechanism and connecting it with the pencil of an indicator upon which a card had been taken, thepencil then being disconnected from the spring; and the diagram superposed upon the indicator card had been interesting to him for years when at intervals he came across it in his notes.

In the case of the Marblehead there were no conveniences for making a diagram as outlined, but it was found easy enough to get the diagram by direct plotting without any other apparatus than a yard stick fastened to one of the guides on which the piston position could be measured and read off, and a pair of dividers by which the movement of the valve could be

measured from the end of the valve chest. A chalk mark on the crosshead and a prick-punch mark on the valve stem were all that was needed on the engine.

The main engines were not disabled by this procedure except that it was necessary to measure the maximum valve opening at the top end which was done in diagram along the ordinate corresponding to the piston position as measured by the yard stick. If the jacking-engine were not stopped on the exact predetermined spot, it made no difference as the exact position of the piston could be read off and the caliper measurements plotted at that point. This will explain two or three



ELLIPTICAL DIAGRAM USED IN SETTING ENGINE VALVES

a very few minutes, one valve at a time. The jacking engine was thrown into gear and the engine turned over until the piston reached the point at which data was desired, when the valve movement was measured with the dividers, between the prick-punch mark and the end of the gland, and this was stepped off on the points which are not just in line with others. As a smooth curve was to be expected from the combinations of these two motions, any error in reading or plotting was caught by the time the next point was plotted, and the point determined again.

The total of perhaps three days' time was spent by

the writer and one engine man in getting the diagram for all six cylinders, and perhaps a day was spent in getting the data on the maximum valve openings at the top end. This is permanent data, and once it is obtained for an engine, the diagrams may be used continuously unless a change is made in the setting of the eccentrics; the eccentrics were not touched in this case, although it might be admitted that slight betterments could have been effected by changing them slightly. If the job could have been done under different circumstances, the ship being under stand-by orders and this data being taken when it could be gotten, between night runs, and target practices and all that sort of thing, the expenditure of time would have been insignificant.

It was a couple of months later before the data was gotten together, digested, and the changes in valve settings agreed upon. The drawings of the valves and valve chambers were studied to be sure that nothing would be wrecked by adjustments made in the lengths of the various valve-stems, which adjustments could easily be made from the outside. The writer's recommendations to the chief engineer were to raise the valves approximately 3/8 in. if possible, but on account of certain clearances, 1/4 in. was about all that was felt safe, and accordingly during a quiet period in Central American waters and between runs the adjustments were made.

The effect upon the maneuvering of the first engine adjusted was plainly noticeable, and likewise the second engine, and quieter running was also noticeable. The effect upon steam economy, as reflected by the coal-consumption, was a little hard to determine, as barnacles were commencing to take free rides and grow up in so doing. Of course the indicator cards showed a much better distribution, but still too much work done by the top end. To get the engine just right would have taken some machine shop work at the yard, and recommendations to that effect made by the writer after he became chief engineer of the ship were turned down because of the age of the ship, and the expectation of very little life from her after the war.

The diagram is nearly self-explanatory. Only the one for one low-pressure cylinder is given, together with the dimensions of the valve from which points upon the diagram were located. It will be noted that in the original plotting, the actual movement of the valve was shown at all points, while the piston movement was plotted to scale, for obvious reasons. The diagram here reproduced has been reduced to about half size.

After the plot was made the distance that the valve was open at the top when in its lowest position for one block setting was measured upon the diagram, and the horizontal line drawn through this point. The valve traveled upward this amount and closed the port. This obviously is the point of cutoff. The valve continued to travel upward and after a distance of about 1½ in. as may be calculated from the drawing of the valve and ports, the port to the bottom end was closed; this determined the compression point of the bottom end. Travel continued for about 1⅛ in. and the release of the top end occurred. Then as the valve traveled upward 1 9/16 in. farther, steam was admitted to the bottom cylinder, and the valve continued upward until the port opening of the bottom end became 2¾ in. by the old setting and 3 in. by the new; these were calculated measurements from the drawing, as obviously there was no way (nor any need) to get under valve without dismantling the engine.

Following the valve on its return stroke, on closing the port for cutoff of the bottom cylinder the valve had of course traveled back the 2¾ in. or 3 in. mentioned above; then down 1 9/16 in. to compression of the top end; then down about 1⅛ in. to release of the bottom cylinder, then 1½ in. down to admission to the top end, and on to the end of the stroke of the valve which gave a full valve opening of 2 3/16 in. by the old setting, and 1 15/16 in. by the new.

The above data were for the maximum valve travel and opening, which was obtained when the block on the go-ahead side of the reversing gear was set for such maximum opening, designated as 0 on the curve. It should have been stated previously, although it may be better stated at this point, that the valve gear of this engine was of the Stephenson link type, using a double bar link of a type which is quite common in marine practice, and that control of the expansion in the cylinder was obtained by adjustment of the position at which the rod connecting the Stephenson link was secured to the reversing gear; an adjustable block at this point determined the point of application of the eccentric motion to the valve stem. Any book on marine engines will show this link block, etc.

The other curves were obtained by changing the block setting, screwing it in the number of inches indicated by the number on the curve.

It should be noted that in the curves, the following points of the indicator cards occur on the same line: admission and cutoff; release and compression; these for one end of course. Just a little thought on what takes place within the cylinder must convince one why this is so, for the meeting of the edge of the valve with the edge of the port is the same for the two grouped together.

From these diagrams, indicator cards may be constructed. For curve 0 the points of cutoff of the indicator cards have been calculated both before and after the change was made, as follows:

	—Before Jan., 1918—		—After Jan., 1918—	
Block	Per cent	Cutoff	Per cent	Cutoff
Position	Top	Bottom	Top	Bottom
0 in.	73	64	71	68
1 "	69	61	66	65
2 "	65	57	61	61
3 "	60	53	56	57
4 "	55	49	51	53
5 "	50	45	45	48½

Of course the cutoff is the most important point in determining the power done in an end of a cylinder; as far as can be seen from a casual study of the diagram, there is nothing out of the way in any of the other points that would be used to make up such a card as would be constructed from this diagram. The table shows that the cutoff points were fairly well evened up by the changes in valve setting. Irregularities in the cards in maneuvering were of small importance compared with the way the engine responded to changes in throttle and reversing gear; we know that better results were obtained. In maneuvering, it is customary to have the block setting at 0 in., for maximum power, regardless

of efficiency; on cruises it was customary to bring the block setting to about 3 in., depending upon conditions, so that maximum economy in the use of steam were obtained in the engine as a whole.

The weight of reciprocating parts was considerable, and on the low-pressure cylinder a mean effective pressure of about 2½ lb. was equal to these parts and should have been obtained in the indicator cards for efficient running; previous to this setting the top pressure had been about this amount higher than the bottom; by the change the two were about equalized. The same conditions were found on all cylinders of the two engines.

It will be noted that the opening of the valve in the case cited is much less for the top end of the cylinder (shown on the bottom of the diagram) than for the lower end. As the engines were built for from two to four times the power that was possible under present conditions, there could be no excessive wiredrawing of the steam through the ports; that is the smaller port was ample. If the engines were to be used for full power, it is quite possible that changes should be made in the valves.

Another point is brought out by this diagram, and that is the relative unimportance of lead. With the new setting the lead at the top end (bottom of diagram) measures about 5/16 in. and for the bottom end 1 3/16 in. Setting valves for equal leads is not uncommon, and it may be that was about the foundation of the difficulties on the Marblehead, which, however, were of small moment.

I presume this diagram could be applied to the setting of valves of a Corliss engine by plotting the movement of the wristplate measured along the arc of the pins of the rods connecting to the valves; on some engines two sets of diagrams would be required, one for the steam valves and one for the exhaust valves.

There are a lot of young engineers going to sea in American ships, men who are more or less technically trained. I feel sure that they will get more out of the elliptical valve diagram when it comes to questions about how and why and whether of the setting of the valves on the engines they deal with, than by any of the older methods, and I commend it to their use.

The theoretical indicator diagram which has been added below the valve diagram is drawn just to show how the adjustments would affect the points in the card, and without regard to the pressures, clearances, and distribution between the different cylinders.

Overhead Distribution Methods*

WITH PARTICULAR REFERENCE TO THE METHOD OF DISTRIBUTING POWER CHARGES AMONG DEPARTMENTS. BY F. BRUGGER

IN DETERMINING manufacturing costs in an industrial plant and in apportioning expenses among the various departments constituting the plant, there are certain items of expense which are more or less difficult to distribute correctly. To allot to each department its proper share of the expenses involved in the cost of manufacturing, it is necessary that an accurate analysis be made of the conditions and methods prevailing in such departments.

Manufacturing costs are the sum of: 1, direct or productive material; 2, direct labor, and, 3, overhead.

Productive material represents material (plus incoming freight) which enters into the manufacture of and becomes part of the finished product and all other material which can be charged directly against individual production orders or classes of product.

Direct labor represents all labor which is performed to change the form or character of materials as purchased to make it conform to orders for manufactured product and all other labor which can be charged directly against individual production orders or classes of product.

Overhead comprises all other expenditures incurred in the operation of a manufacturing plant which are not properly chargeable to selling expenses or its general administrative expenses.

In the classification of expenses the extent to which overhead should be sub-divided to provide for proper expense control depends entirely upon the magnitude of the concern and the nature of its products.

Co-operative departments such as maintenance, receiving, shipping and administrative departments should be treated in exactly the same manner as the manufacturing departments, that is, they should be charged with all expenses incurred by and for them. Many items of expense can be charged directly against specific departments without recourse to apportionment. There are, however, some items of expense which cannot be charged directly, such as the wages of watchmen, gatemen, firemen, the cost of welfare work, water supply, taxes, insurance, power, heat and light, and depreciation. Each of these items should be analyzed carefully and a suitable basis for distribution determined.

To illustrate the manner in which this may be done, the following suggestions are offered: The expense, for instance, of maintaining a fire department and the cost of insurance should be distributed to the various departments on the basis of capital invested in each departmen modified by the fire risk involved. For example, if the amount of capital invested in one department is three times as great as that invested in another department, both being subject to the same fire risk, it is no more than fair that the former should be charged with three times the insurance expense charged to the latter. If, however, the danger of fire in the latter department was, say, twice as great as in the former, the insurance expense charged against the latter would be two-thirds that charged against the former.

The total cost of supplying water to the factory should be divided among the departments on the basis of the amount of water consumed in each department. In departments which use large quantities of water, separate meters should be installed to insure proper distribution.

POWER AND HEAT

TO DETERMINE the real cost of this item it is important that manufacturing plants producing their own

*Abstract of paper delivered before the New York section of the Industrial Cost Association.

power, light and heat should treat power plants as entirely separate organizations, charging to them all expenditures incurred, not only items such as labor, fuel, water, maintenance, etc., but also insurance, taxes, depreciation and their proper share of factory administrative expenses. An efficient cost system should be installed to determine:

(a) Cost of steam per 1000 lb.

(b) Cost of electrical energy per kilowatt-hour.

As far as practicable, each department or group of departments using large quantities of steam or current should have its own steam flow meters and watt-hour meters, to determine actual consumption.

Further segregation of cost is often necessary, in order to secure adequate distribution. As a suggestion the following basis of apportionment applicable to a large electrical manufacturing plant is given.

Compressed air is charged on the basis of full time men in departments using it, making due allowance for the nature of equipment employed in each department.

Steam for manufacturing is charged on the basis of water passing through steam traps located in various departments. Steam for heating on the other hand is charged for on the basis of floor space occupied by each department modified by the degree of heat maintained. For example, there should be a smaller charge per square foot of floor space in the foundry than in an office.

Electric current used in the plant is divided into three separate heads, current used for testing, current used for power purposes and current used for lighting. That used for testing is charged for on the basis of meters installed in the various testing departments. Current used for power purposes is charged for in accordance with the total horsepower capacity of motors installed in each department. Current for lighting is charged for on the basis of floor area occupied by each department, modified by the degree of lighting required.

Taxes and Depreciation

When considering taxes, charges are made on the basis of assessed values of the plant, equipment and inventories of each department. In cases where the same building is occupied by more than one department, the assessed value of the land and buildings should be pro-rated over the departments occupying it, on the basis of the floor area used by each.

Depreciation differs from the other items of expense in that it does not agree with any actual expenditures made during or for a given period. It represents an estimated amount of shrinkage in the value of the plants and equipment due to wear and tear as well as due to obsolescence. The proper determining of the amount of depreciation requires the segregation of capital expenditures into well-defined classes, for each of which a normal rate of depreciation can be determined upon, dependent upon original cost, expected length of service or life, scrap value and liability to obsolescence. These rates, being estimates, require constant checking and are subject to change not only when errors in judgment of expectation of average life of each class of equipment are detected, but also when it is apparent that, due to extraordinary activity, especially heavy wear and tear is experienced and equipment is purchased in excess of capacity required during normal periods, possibly at higher costs than those prevailing in normal times.

The amount of depreciation chargeable to each department is determined by applying to the appraisal value of each class of capital investment the rate of depreciation previously determined upon. Depreciation on buildings, wiring, piping, exclusive of that installed specifically for the benefit of a definite manufacturing department, should be distributed over the departments occupying the building, on basis of floor area used by each.

Steam Used for Soot Blowing

Method of Calculating Steam Consumption When Time Valve Is Open Is Known. By Robert June

ONE of the outstanding features of the mechanical soot blower with an automatic valve at the entrance to the unit (Fig. 1) is the steam-saving effected by the unit valve being open just long enough to have the jets pass over the part of the tubes to be cleaned. With the cam adjusted to hold the valve open for 300 deg. the head uses steam from 5 to 7 sec. per revolution. As the gear reduction assures turning of the element slowly and steadily, it is rarely necessary to revolve the blower more than two or three times. This means that steam is being used from 15 to 21 sec. per unit per blowing.

In contrast, the valve of the plain revolving soot blower is necessarily open from 45 to 75 sec., 60 sec. being the average time required for close attentive operation.

At this point it is well to observe that very few men operating soot blowers realize the importance of giving proper attention to the steam loss due to unit valves being kept open longer than necessary to clean the boiler properly. We have timed a large number of soot blower operations, many of them without the knowledge of the operator, and it has been surprising to note the frequency with which the unit valves are kept open 2 and 3 min. and even longer, while keeping the valves open from 1½ to 2 min. is common practice. Figure 2 is a chart from which the steam loss from excessive blowing can readily be computed. The vertical column of figures at the left is the steam pressure in the header when blowing, while the figures at the bottom show the amount of steam that will pass through a standard 5/16-in. soot blower nozzle at the various pressures in a given time.

The point at which the slanting lines intersect vertical lines for a given pressure indicates the steam flow through the nozzle for the time marked on each slanting line. By this method we find that with 100 lb. header pressure, 2.4 lb. of steam will flow through a nozzle if the valve is open 30 sec., while 9.6 lb. will be used if the valve is left open 120 sec.

Taking a standard B. & W. boiler 21 tubes wide, we find we have five units of 20 jets each or 100 jets.

To blow this boiler by the automatic valve system with the valves open 30 sec. each will require 240 lb. of steam, while with the independent valve soot blower if the valves are open 120 sec. each, 960 lb. of steam will pass through. If the boiler can be properly cleaned with the valves open 30 sec., the loss would be 720 lb. per blowing, or 2160 lb. in 24 hr., if the blowers were used three times a day. With the boiler in service 300 days a year, the steam loss would be 648,000 lb. To reduce this loss to dollars and cents it is only necessary to

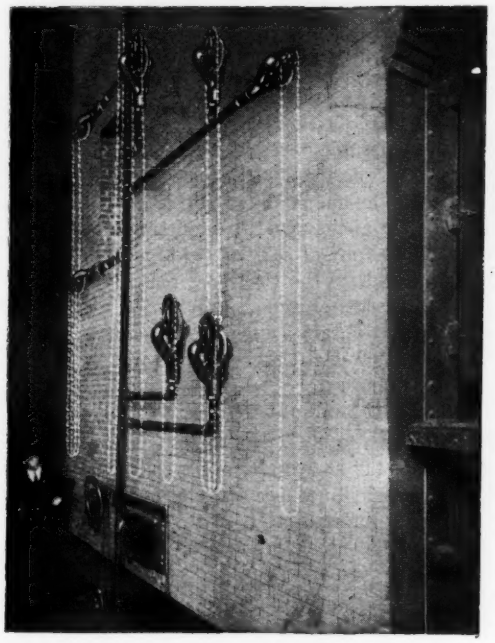


FIG. 1. SOOT BLOWER WITH AUTOMATIC VALVE AT ENTRANCE TO UNIT

multiply the cost of the steam from 20 to 70 cents per 1000 lb. by 648. If the steam costs 50 cents per 1000 lb., the loss for the boiler described above would be $324.00 per year.

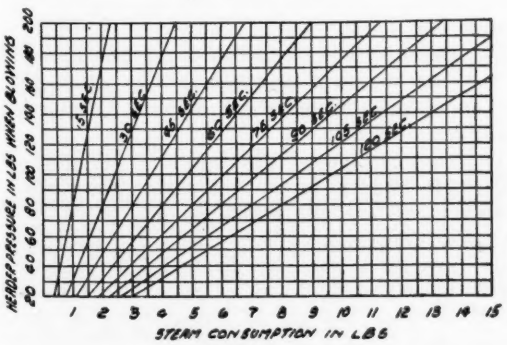


FIG. 2. STEAM CONSUMPTION FOR SINGLE 5/16 IN. JET STEAM PRESSURE 40 TO 100 LB. WHEN BLOWING, VALVE OPEN 15 TO 120 SEC.

The chart Fig. 3 shows the total steam consumption for five-unit, 21-wide installation, on which the header pressure is 100 lb. with the unit valves open from 10 to 130 sec. Figure 4 shows the total steam consumption of installations on a 21-wide boiler with 100 lb. header pressure, having from 1 to 15 units and blowing from 15 to 120 sec. each. From this it will be seen that a boiler with 14 units, having 20 jets each, and with 100 lb. header pressure, will require 690 lb. of steam

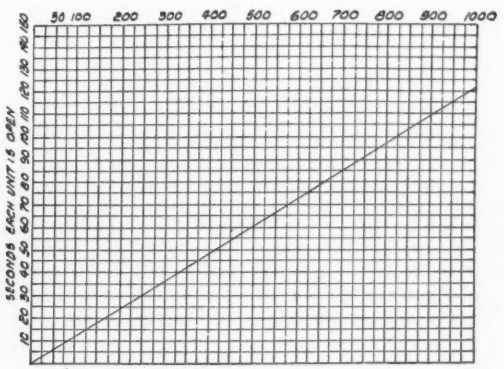


FIG. 3. STEAM CONSUMPTION IN POUNDS PER 5 UNITS ON BOILER 21 TUBES WIDE, 100 LB. HEADER PRESSURE WHEN BLOWING

per blowing, if the valves are open 30 sec. each, while 1725 lb. will be required if the valves are left open 75 sec. each.

It should be noted that the pressures given are for the header while blowing. With one unit valve open the header pressure will be from 50 to 80 per cent of the boiler pressure, depending on the size of the piping, the bends and valves in the line, the number of jets on the unit and other conditions. The header pressure

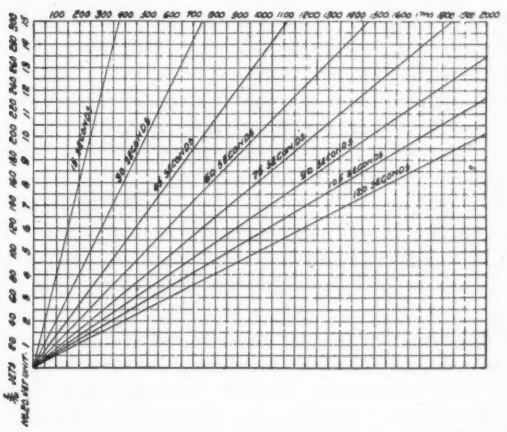


FIG. 4. STEAM CONSUMPTION PER UNIT FOR BOILER 21 TUBES WIDE, HEADER PRESSURE 100 LB. WHEN BLOWING, VALVE OPEN 15 TO 120 SEC.

will always be somewhat higher than the pressure in the blower element, due to friction between the header and the element and in the element. This will also account for the discrepancies between these charts and the results obtained by the use of Napier's Formula.

These charts have been compiled from data collected while making tests on soot blowers at one of the largest power plants in the United States under conditions which assure their accuracy.

Notes on British Power Plant Practice

EXPERIMENTS WITH PEAT; DISCUSSION OF METHODS OF IMPROVING INTERNAL COMBUSTION ENGINE EFFICIENCY. BY C. H. S. TUPHOLME

IN VIEW of the serious aspect of the fuel situation in Britain, especially where industrial power plants are concerned, great interest is attached to the possibilities of employing peat fuel. Accordingly experiments have just been carried out to determine just how far peat could be utilized on an economic basis.

Last year a quantity of peat at Turraun in Ireland was macerated and spread on the bog. The peat was air-dried and sent to London in hard blocks 10 in. long, with a cross section about 2 in. square, for research. Their density was rather under one, or about twice that of ordinary hand-cut peat sods. These blocks could be sawn and cut like hard wood, and had stood transport with very little breaking up. On arrival, the water content of the blocks was about 25 per cent, but this was reduced by a few months of storage under cover to 17 per cent.

It was found by experiment that not only do these peat blocks lend themselves admirably, after suitable treatment, to carbonization in vertical retorts at temperatures between 750 and 850 deg. C., but also in steel retorts at 550 and 600 deg. C., and the resultant charcoal is an ideal fuel for suction gas producers.

The first stage in the experiments was the preparation of the peat for carbonization. Before dealing with the bulk, a small portion was tested under the coal crusher and disintegrator, a considerable quantity being reduced to dust. The larger pieces after crushing were about 2 by 2 by 1 in. After breaking up, the dust was not separated but passed into the retorts with the peat.

Carbonization was first carried out at a temperature of 1000 deg. C., four retorts in a setting being employed. A throughput of 3 T. per retort per day was aimed at and a quantity of steam was supplied to the base of the retorts sufficient merely to quench the coke before it was extracted. It was found by trial that 6 per cent of steam by weight of the peat carbonized was sufficient for this purpose. The volume of gas passing away from the top of the retorts under these conditions was very great so that it was with difficulty that a positive pressure in the retorts and collecting main was avoided. It was found impossible to reduce the pressure below about 0.1 in.

Charging the retorts in these circumstances was a matter of considerable difficulty and discomfort to the stokers. The entrance through the coal valve into the feed hopper is so small in the Glover-West fittings that the peat had to be poked down through the hole to prevent arching across. This necessitated the stoker standing immediately above the valve while poking (about 5 min. in every 20 min.) and directly in the way of the large volumes of gas which issued from the coal valve due to the pressure in the retorts. The gas had a peculiarly unpleasant effect on the mouth and nostrils. This difficulty would not, of course, arise in a plant specially designed for peat, as it would be quite a simple matter to design an arrangement suitable for charging under these conditions.

The high percentage of dust in the crushed peat caused trouble owing to its being carried forward into the gas main by the rush of gas. This dust formed a thick mass with the tar, and in one instance constituted a serious blockage.

Owing to the coke formed being only about 30 per cent of the peat charged, it was necessary to reduce the rate of revolution of the coke extracting screw almost to the minimum in order to obtain a throughput as low as 3 T. per retort per day.

The coke or charcoal came out in much the same form as that in which the peat entered the retorts but very much reduced in volume, the weight being 28 per cent of the peat as charged. The amount of dust in the charcoal was not excessive.

The retorts were treated in quite a satisfactory manner by part of the gas made during the tests, the amount required being about one-third of the total make.

At a throughput of 3 T. of peat per retort per day, it was found that the limit of the capacity of the exhausting plant had been reached. In order to obviate this difficulty and to obtain a longer period of test, a second test, at 800 to 900 deg. C. was carried out on two retorts only. The same rate of carbonization was employed, giving a total throughput of 6 T. per day.

The condensing and separating arrangements provided for coal tar and liquor were found unsuitable for the peat tar and liquor because the peat tar was lighter than the peat liquor and special arrangements had to be made for the collection of the former.

The gas and vapor entered the water-cooled condenser at 80 deg. C. In order to prevent an unmanageable quantity of tar and liquor getting forward with the gases, it was found necessary to reduce this temperature on leaving the condenser to about 20 deg. C. This was well below the setting point of the peat tar (40 deg. C.) so that the liquid products issued from the condenser in the form of a yellow emulsion. This had again to be heated up to about 50 deg. C. in order to obtain a separation into peat tar (a black oily liquid) and liquor. On cooling to atmospheric temperature, the tar set into a black semi-solid mass showing crystals of paraffin wax.

The volume of liquor collected per ton of peat carbonized was large and therefore low in ammonia content compared with normal gas liquor. In color it was a clear bright yellow.

The consumption of peat gas on the retorts was 3480 cu. ft. per hr. in the first test. Therefore on a throughput of 3 T. per retort per day it will be seen that after supplying sufficient heat for carbonization of the peat there were for disposal from each ton of peat 26 therms (7940 cu. ft. of gas of 325 B.t.u.), 12.6 gal. of tar, and 95½ gal. of liquor of 3.6 oz. strength per ton, and 5.4 cwt. of charcoal.

It is possible that the figure given for consumption of gas as fuel to the retorts is low, as these had not actually reached a state of equilibrium by the time that the tests were completed. The difference is, however, unlikely to exceed 5 per cent.

The main details of the test are set out in the following table:

	Test No. 1	Test No. 2
Duration of test, hours	18	52
Carbonizing temperature	980 deg. C.	820-875 deg. C.
Number of retorts in use	4	2
Total peat carbonized (tons as charged)	11.01	12.39
Steam to retorts per cent of peat carbonized	6.5	6.0
Gas—		
Total make, cubic feet	164,100	170,610
Yield per ton of peat, cubic feet	14,900	13,760
Heat value of gas per ton of peat, therms	48.4	46.8
Calorific value (gross) in B.t.u. per cubic foot	325	340
Calorific value (net) in B.t.u. per cubic foot	296	310
Specific gravity (air = 1)	0.746	0.757
Total CO_2 per cent by volume	17.8	18.2
Charcoal—		
Total produced, tons	2.96	3.34
Per cent of weight of peat	26.9	27.0
Volatiles less moisture per cent	3.13	3.96
Ash, per cent	9.17	9.98
Tar—		
Total dry tar made, gallons	138.2	264.0
Dry tar made in gallons per ton of peat	12.6	21.3
Specific gravity at 15 deg. C.	0.996	0.985
Liquor—		
Total made in gallons per ton of peat	95.5	87.5
Water supplied to scrubber, gallons, per ton	20.9	25.5
Strength in ounces	3.6	3.3
Ammonium sulphate, pure, lb. per ton	29.2	24.8

The temperature in the setting of the flue gas circulating chambers was below 700 deg. C. throughout both tests. The temperature in the combustion chambers averaged 997 in Test 1, and from 820 to 875 deg. C. in Test 2.

The peat analyzed as follows:

Proximate analysis as charged—	Test 1	Test 2
Moisture	20.20	20.03
Organic volatile matter	49.53	49.64
"Fixed carbon"	26.83	26.66
Ash	3.44	3.67
	100.00	
Ultimate analysis of dry peat—		
Ash	4.31	4.59
Carbon	57.48	57.69
Hydrogen	5.55	4.90
Sulphur	0.53	0.49
Nitrogen	1.33	1.51
Oxygen	30.80	30.82
	100.00	

Calorific value—		
B.t.u. per lb. as charged	7650	7710
B.t.u. per lb. dry	9590	9640

The analysis of the peat charcoal is shown hereunder.

	Test No. 1	Test No. 2
Proximate analysis as made—		
Moisture	9.40*	3.37
Organic volatile matter	3.13	3.96
Fixed carbon	78.87	82.69
Ash	8.60	9.98
	100.00	
Ultimate analysis (dry)—		
Ash	9.49	10.33
Carbon	85.78	84.81
Hydrogen	0.52	0.39
Sulphur	0.60	0.61
Nitrogen	0.42	0.53
Oxygen	3.19	3.33
	100.00	
Calorific value, B.t.u. per lb.—		
As discharged	11,380	12,210
Dry	12,560	12,650

* Owing to incomplete quenching part of this sample had to be watered, which accounts for its relatively high moisture content.

In this investigation, peat containing to 20 per cent of moisture has been carbonized at temperatures varying from 820 to 1000 deg. C. In Test No. 2 there was a steady fall in carbonizing temperature throughout the whole test from about 880 to 830 deg. C. and this fall must be taken into account when comparing the results of Test No. 1.

Improving the Efficiency of the Internal Combustion Engine

The great majority of internal combustion engines, says H. E. Wimperis, of the Institution of Mechanical Engineers, works on the four-stroke constant-volume cycle, the efficiency of which is higher, the higher the compression ratio. Thus, taking a normal gas and air mixture we get:

Compression Ratio	Theoretical Efficiency (Gas Standard)
4	0.341
7	0.443
10	0.498

Compression ratios of between 4 and 7 are usual, and over four-fifths of these theoretical efficiencies are already attainable in practice, giving but little room for further improvement unless some radical change is made.

A question which may be asked is: Why not increase the fuel economy by change of working medium, or, if that is not possible, by changing the operating cycle?

The air standard efficiency expression is:

$$n = 1 - \left(\frac{1}{r}\right)^{\gamma - 1}$$

where r is the compression ratio and Y the ratio of the two specific heats. Most internal combustion engines are in effect nitrogen engines, that is to say, the bulk of the stuff inside the engine at any time is nitrogen. It is nitrogen that receives heat from the burning fuel: nitrogen that expands and does work; nitrogen that is

exhausted. Nitrogen is a diatomic gas and has a specific heat ratio of 1.40 corresponding to a fixed division of the molecular energy between translation and rotation. It may seem, therefore, that it would be a gain to select instead some monatomic gas, since in that the whole of the molecular energy would be in motion of translation and the specific heat ratio would rise to 1.667; so that the theoretical efficiency for compression ratios of either 4 or 7 would rise by about one-third part. But it is not possible to treat this problem as physical only. There is also a chemical side to it, and a high value for the specific heat ratio means a high compression temperature leading to pre-ignition and detonation difficulties. If instead we work to a limit of compression temperature (or, for a given mixture strength, the explosion temperature, which is suggested by Tizard as the best guide toward the avoidance of detonation and knocking), the equation becomes:

$$n = (T_1 - T_0)T_1$$

where T_1 is compression temperature and T_0 the suction temperature.

Into this expression the specific heat ratio does not enter; hence the suggested change of the working medium has not helped at all and the familiar nitrogen still holds the field. An increase of efficiency by increase of compression ratio has been shown to be attainable if the maximum temperature be limited by adding a certain proportion of cooled exhaust products to the charge. Moreover, some fuels are much less liable to detonation than others.

Ricardo has lately investigated the degree to which various possible fuels are capable of reducing the liability to detonation when, to reap the advantages of high thermal economy, high compression ratios are employed. He has also made the useful suggestion to cause the expansion ratio to be greater than the compression ratio by delaying the closing of the inlet valve.

Something must be said on the theoretical limits to what is possible by change of cycle, leaving the working substances as they are. With the ordinary internal-combustion engine the maximum temperature range is from 1800 to 100 deg. C. For such a range Carnot's theory shows that the maximum theoretical efficiency is 1700 ÷ 2073, or 82 per cent. This is fully double our present standard, and it shows that if only all losses could be suppressed and all the heat energy supplied at 1800 deg. C. and exhausted at 100 deg. C., the work done per pound of fuel could be increased 100 per cent.

Cheap Lubricating Oil

By W. F. Schaphorst*

IT ALWAYS pays to use a good grade rather than a poor grade of lubricating oil. Never buy oil simply because it is cheap because it may prove, in the end, to be expensive.

In many instances it has been found that by abandoning the use of a cheap lubricant and substituting a higher grade although slightly more costly lubricant, the friction load has been reduced 20 per cent or even more, which may be a considerable item in many plants.

The first question, however, that the owner or official may ask is: "What is my friction load and what will be the dollars and cents saving per year if I can reduce my friction load as much as 20 or 25 per cent by using a higher grade oil?"

To determine the friction load, possibly the best method is to use a steam engine indicator if the plant is driven by a steam engine, or if it is motor driven it is a simple matter to determine the friction load by simply taking readings on the switchboard with all machines running, but running "empty." That is, the friction load is the power required to drive all machines in the plant while they are "unloaded" and are not doing any useful work. If the steam engine indicator shows that the friction load is 10 hp., it means, of course, that 10 hp. are required to drive all of the machines empty and it means that this much power is being used for overcoming the friction load all day long even when the machines are loaded. The useful work is simply an additional load added to the friction load, the friction load being practically constant all the time. The same is true for motor driven machines as well as for steam engine driven machines.

If, for example, it is found that the friction load in your plant is 10 hp., and the cost of power is only 2c a horsepower per hour, the cost of the friction horsepower alone would mean 20c per hour, or $2 per 10-hr. day. Assuming 300 working days a year, the cost of the friction horsepower a year would be $600. Then if it is possible to reduce the friction load by 20 per cent by using a better lubricant, the saving per year would be 0.20 × $600. = $120 in power alone. In addition to this, the reduction in friction load means that there would be less wear in the bearings, the belts would be capable of pulling a greater load because they would not be stressed so much, and altogether the saving would amount to more than $120 a year. For that amount of money a great deal of lubricant can be purchased and it surely becomes evident that it pays and pays well to spend "just a little more" money, if need be, for a higher grade of lubricant.

Of course, it is foolish to pay a high price for oil for the mere sake of paying a high price. If indicator or switchboard tests show that the more costly lubricant does not reduce the friction load, it is good economy to go back to the former and less expensive oil. In fact, the writer knows of instances where less costly oil has actually given better results than a higher priced oil in the matter of friction load, thus creating a triple saving—the saving in cost of oil, the saving in cost of power, and the saving in cost of wear and tear.

Nine times out of ten, where much lubricant is used and where economy is desirable, this matter is worthy of careful investigation.

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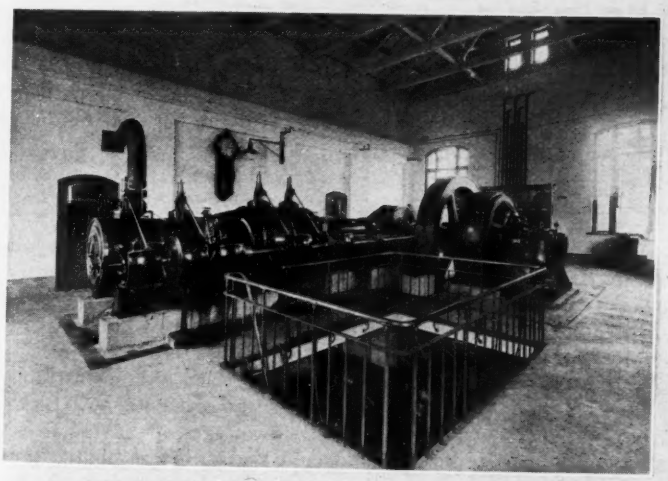
St. Lawrence Canal and Water Power Project was the subject of a report recently sent to Congress by the International Joint Commission. The Commission recommended that the project be undertaken jointly by the United States and Canada without delay. Accompanying the commission's recommendation is a voluminous report by waterway engineers describing the undertaking in detail and estimating its cost. The plan provides for 33 mi. of canalization of the St. Lawrence River at an estimated cost of $252,725,000, which amount it is proposed to recover from the sale of electric power developed along the seaway.

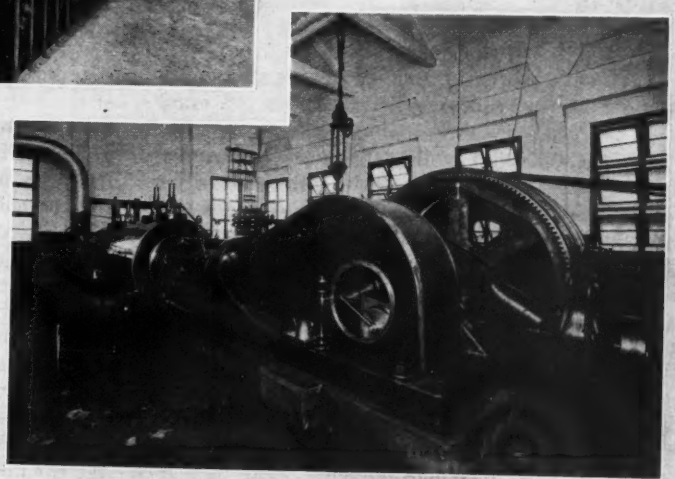
Views of American Power Plant Equipment as Installed in Japan

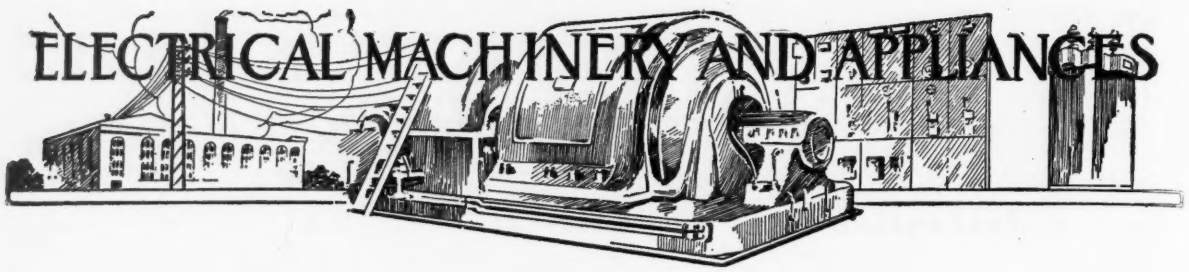
Right. View in engine room at the Oriental Paper Mill, Osaka, Japan. The engine shown is a 17½ and 30 by 30 in. 550 hp. unit equipped with a jet condenser.



Left. A 200 kw. d. c. generator driven by a 15½ and 26 by 27 in. engine at the plant of the Tobacco Monopoly Bureau, Okayama, Japan.

Right. A 21½ and 36 by 36-in. engine at the plant of the Taniguchi Spinning Co., Yoshimi, Japan.





Direct Current Armature Windings---I

DESCRIBING IN DETAIL THE DIFFERENCE BETWEEN THE TWO IMPORTANT TYPES OF ARMATURE WINDINGS. BY MARIN PHILLIPS

DIRECT CURRENT armature windings are classified according to the manner in which the inductors are wound on the armature core; these methods being divided into four distinct classes, namely: the ring winding, the pole winding, the disk winding, and the drum winding. These four types are illustrated in Figs. 1 to 4.

Of the four types of windings mentioned, the drum winding is the most extensively used, and will be explained to greater length than the other three types, which are practically obsolete now, excepting on some old type machines.

Figures 1, 2 and 3 are shown here merely to show what progress has been made in the last decade or two,

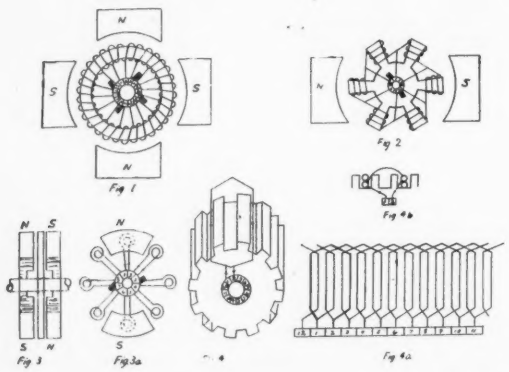


FIG. 1. THE RING WINDING. FIG. 2. THE POLE WINDING
FIG. 3. THE DISK WINDING. FIG. 4. THE DRUM WINDING

by designing engineers in developing the present type of drum wound armatures to their high state of perfection. Taking the four types of windings in the order named, their main advantages and disadvantages may be summed up as follows:

Ring winding advantages: It is well suited for high voltage work where too high a current is not required, thus making it well adapted for use as an arc light generator. It is very simple and easy to ventilate. It is free from complicated commutator connections. A defective coil can be located and repaired easily without interfering with the rest of the winding. Disadvantages: Not well suited to carry high currents. The inductors which lie on the inner side of ring are practically screened from the magnetic lines of force, which prevents about one-half of the armature inductors from being active. This adds to the expense and size of the machine by having to wind on about twice as much wire in order to obtain the desired results. The coils have to be wound on by hand which makes the winding slow and expensive.

Pole winding: The self induction generated in each section of the winding gave so much trouble from sparking at the brushes that this type of winding proved a failure on direct current machines, but was used to some extent on old types of alternating current generators.

Disk winding: Nothing much can be said of this type of winding as it was not used very much, although it had one interesting feature, not having to have magnetic conducting material between the pole faces. The coils were arranged in disk form as shown in Fig. 3 and 3-a, without the use of an iron core on a plane perpendicular to the shaft, the coils revolving between the pole pieces in a narrow slot.

THE DRUM ARMATURE WINDING

HAVING REVIEWED the old type of armature windings, we shall now take up the drum type of armature winding, which is in general use today on all types of motors and generators. Before leaving the old types of windings, however, it might be well to state that the ring wound armature possessed some good points and would probably be used to a great extent today if it were not for the two great disadvantages, of having to wind the coils on by hand, and the inductors on the inner side of the ring being practically screened from the magnetic lines of force. The drum armature is built up of a great number of round plates, cut out of very thin sheet iron by a machine which at the same time cuts the slots for the coils to lie in. The thin sheet iron wheels or disks are assembled on a form, which brings the slots in line for the coils to lie in. When the armature is built up to the required length, it is either bolted or riveted together, pressed on the shaft and carefully balanced to prevent vibration after the machine is completed and in operation. Figure 4 shows what the finished armature looks like, and the method of placing the coils in the slots. Only one coil is shown for the sake of illustrating the general appearance of the armature, but the complete winding for the 12-slot armature is shown in full with its connection to the commutator in Fig. 4-a. Figure 4-b shows how the left-hand side of coil No. 1 which is drawn heavy, lies in the bottom of slot No. 1,

and the right-hand side lies in the top of slot No. 3, with the left-hand side of coil No. 3 under it, and so on all the way around the armature.

Direct current armature winding appears to be a very difficult operation, which is not the case, however, if a few fundamental principles and rules are thoroughly understood and mastered at the beginning. For the benefit of those who are not familiar with direct current armature windings, I would suggest getting a large spool, which can be made to represent a 12-slot armature by driving 12 tacks or small nails in one end of the wooden shaft for commutator bars. This spool may be used as an aid in grasping the principle of armature winding, which will make our calculations in figuring the winding of a given machine more easily understood. Taking our dummy armature, and a ball of string, we now select a slot and call it slot No. 1, then skip one slot and call the next one slot No. 3. Next select a nail about midway between slot No. 1 and No. 3 and call it commutator bar No. 1. Tie the string on the nail selected as No. 1 commutator bar, and carry the string through slot No. 1, then across the back of armature to slot No. 3, and through it to the front.

This completes one turn of the coil, which can be made up of as many turns as necessary. In this case, however, we will use a 5-turn coil, made by winding the string around as described five times. The beginning of this coil is connected to commutator bar No. 1 while the end is connected to bar No. 2, which will be the next bar to the right of No. 1. From commutator bar No. 2 wind five turns in slot No. 2 and No. 4, and connect the end to commutator bar No. 3 and so on all the way around the armature. According to the diagram, Fig. 4-a, when the last coil is wound on, the end of it

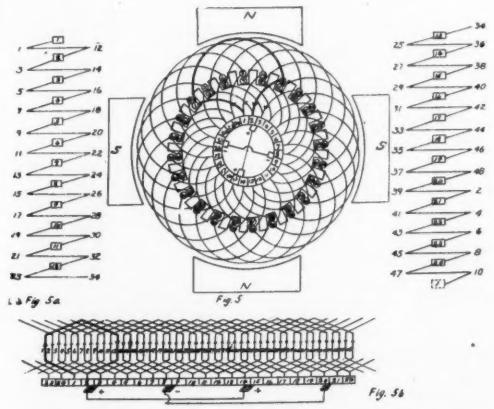


FIG. 5. DIAGRAMMATIC REPRESENTATION OF A 24-SLOT DOUBLE LAYER 4-POLE, SIMPLEX, 4-CIRCUIT PROGRESSIVE LAP WINDING

will connect to commutator bar No. 1, which will complete the winding by having the 12 coils connected in series. While this winding may seem very simple, if it is thoroughly understood it will be a great help towards making the more complicated windings clear. This winding is known as a double layer simplex lap winding. A double layer winding has more than one coil side in a slot, and in this particular winding there are 10 wires in each slot. This could also have been accomplished by making six coils with 10 turns, instead of 12 coils with five turns, but it would then have been a single layer winding with one coil occupying two slots.

There are many different methods to be used in winding direct current armatures, but the two types known as lap winding and wave winding are the ones that are in general use on most types of machines. These two general types may further be classified in the following manner, according to the number of independent windings on the armature: Lap winding—simplex, duplex, triplex, quadruplex. Wave or two circuit winding—simplex, duplex, triplex, quadruplex, sextuplex.

The Lap Winding

Of the two types just referred to, the lap winding is probably the most used type, as it is well adapted for low voltage armatures which have to carry heavy currents. The lap winding differs from the wave winding in two general ways. First, it must be provided with as many brush holders as there are field poles, on account of there being as many circuits or paths through the armature as there are poles. Second, the manner in which the coil leads are connected to the commutator bars. The general difference between the lap and wave or two-circuit windings is shown very clearly in Fig. 5 and 5-b and 6 and 6-b. Figure 5 shows a 24-slot double-layer 4-pole simplex, 4-circuit progressive lap winding.

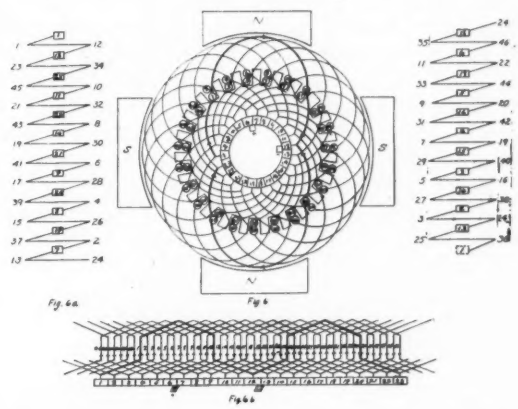


FIG. 6. DIAGRAMMATIC REPRESENTATION OF A 23-SLOT DOUBLE LAYER 4-POLE, SIMPLEX, RETROGRESSIVE WAVE WINDING

Figure 5-b shows the same winding split between the slot 1 and 24 and spread out. The brushes are shown on the inside of commutator for the sake of clearness.

Figure 6 and 6-b shows a 23-slot double layer 4-pole simplex retrogressive wave winding. Figure 6 is only shown now as an aid in explaining the difference between a lap and wave winding. By inspecting Fig. 5, let us start at commutator bar No. 1, which has the beginning of coil No. 1 drawn heavy, as shown, to indicate at a glance how the coils lie in the slots connected to it.

We now trace this lead or coil end from bar No. 1 to inductor No. 1, then around this coil as many times as there are turns. After all the turns have been traversed, the end, which is called the coil lead is now brought back and connected to commutator bar No. 2. By inspecting this coil it is plainly shown how one side of the coil lies in the bottom of slot No. 1 while the other side lies in the top of slot No. 6, and that the beginning of

the coil starts at commutator bar No. 1 and ends at bar No. 2. Now take the next coil to the right of No. 1 coil and call it coil No. 2, which starts at commutator bar No. 2 and ends at bar No. 3. In a similar way trace out the entire winding around the armature in a clockwise direction. When all the coils have been traversed, the end of coil No. 24, which is the last one to trace out, will connect to commutator bar No. 1, which brings us back to the starting point. It will now be seen that the entire winding has been connected in series all the way around the armature, and closes on itself at commutator bar No. 1.

The Wave Winding

Now by inspecting the wave winding, Fig. 6, and tracing out each coil, it will be seen that a different method is used in connecting the coil ends to the commutator bars than was used in the lap winding. To trace out the wave winding, let us start at commutator bar No. 1, which has the beginning of coil No. 1 connected to it. Follow the lead to inductor No. 1, which lies in the bottom of slot No. 1, and from this inductor to inductor No. 12, which lies in the top of slot No. 6. Now here is where the difference between the lap and wave winding becomes apparent. Instead of the coil lead which is the finish of coil No. 1 from inductor No. 12, lapping back to commutator bar No. 2, as it did in Fig. 5, it advances forward and connects to commutator bar No. 12, which is halfway around the armature from commutator bar No. 1. Then follow from commutator bar No. 12 to inductor No. 23, to inductor No. 34, to commutator bar No. 23, which completes one trip around the armature. By tracing out the entire winding, it will be seen that every time a coil is traced around the armature, the connection to the commutator will fall back one bar. First starting around from bar 1 to 23, second, starting from bar 23 to 22, etc., until all 23 coils have been traced out. After all the coils have been traced out, the winding will close on itself at commutator bar No. 1, as it did in the lap winding.

By studying Figs. 5 and 6 it will be seen that the general difference is in the way that the wave winding advances around the armature, and that in the lap winding an inductor under the north pole is connected to an inductor under the consecutive south pole, then back to an inductor under the north pole. By this arrangement of winding the coils under each pair of poles form a circuit by themselves, and the different circuits are put in parallel by the brushes, which makes the lap winding well suited for low voltage armatures which have to carry a heavy current. But in the wave winding the coils are connected in series under poles of like polarity. In the 4-pole winding that we are now discussing, there are two north and two south poles.

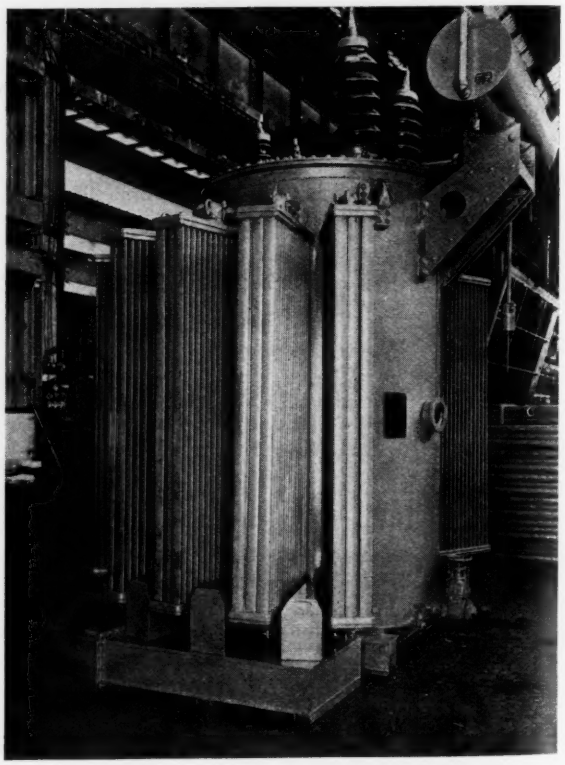
The coil shown drawn heavy under the north pole at top of diagram is connected in series with the heavy coil under the other north pole. In a 6-pole machine there would be three coils in series, and in an 8-pole machine, four coils in series, etc. In making one trip around the armature, for instance, in the 4-pole machine, we have two coils connected in series under the two north poles and all the other coils are similarly connected.

It is therefore evident that the electromotive force generated in one coil will be added to the electromotive force generated in the other coil. We will assume, for example, that one coil generates 10 v., then two coils in series will generate 20 v. This is why the wave winding is sometimes called a two-circuit or series winding, as it has only two circuits regardless of the number of poles. The wave wound armature, shown in Fig. 6, will generate 230 v., while if it had been a lap-wound armature there would have been four circuits in parallel, which would only generate one-half the voltage or 115 v.

This explanation it is hoped will make clear the difference between the wave and the lap winding. These two types of windings as stated previously may be subdivided in simplex, duplex, triplex, etc., and in a subsequent article the author will endeavor to explain the method of calculation employed in laying out such windings.

Emergency Operation of Self-Cooled Transformers

On account of self-cooled transformers being designed on an ambient temperature of 40 deg. C., advantage of the full rating of the transformer may not be obtained where temperatures are above this point. Such a case happened in a sub-station of the



SHOWING METHOD OF DIRECTING FLOW AIR BETWEEN RADIATORS OF TRANSFORMERS

Southern California Edison Co., so that artificial cooling was necessary. To meet the conditions, air ducts were installed around the base of the 5000-kv.a., Westinghouse single-phase, maximum rated, self-cooled radiator type transformer, so arranged with openings placed between the radiators to direct the flow of air supplied by a motor driven blower.

With this method of artificial cooling, these maximum rated transformers will carry 25 per cent overload continuously with the same winding temperatures as at full load without artificial circulation of air.

The transformer is provided with a hot spot temperature indicator, an oil expansion tank and a high voltage tap changer, the latter operated by a hand wheel in a convenient position above the transformer cover.

The Three-Phase, Four-Wire Distribution System

Outlining Its Advantages and Methods of Changing Over from Old Systems

THE THREE-PHASE, four-wire system is more economical than other 2300-v. single, two or three-phase systems, according to Thomas Sproule, assistant to the general superintendent of the Public Service Electric Co. of Newark, N. J. In a paper read at a joint meeting of the Metropolitan Section of the American Society of Mechanical Engineers and the New York Section of the American Institute of Electrical Engineers, Mr. Sproule stated that this economy was due to the fact that more power can be delivered over a given weight of conductor, the regulation is better, larger areas can be served, the power loss is less, the voltage drop is less, and additional load can be added at less cost.

"The three-phase, four-wire system of distribution," Mr. Sproule declared, "is a three-phase star connected system, usually designed to deliver 2300-v. service between the neutral and each phase wire and 4000-v. service between phase wires, although any other voltage may be used. In comparing this system with others, it is proposed to consider different types of systems utilizing transformers of similar voltages only.

"While many instances can be cited where changes have been made from old systems of distribution to the three-phase, four-wire system, the majority of such changes have been brought out because of the necessity for increased capacity in the distribution plant. When it is realized that the capacity of a two-phase, four-wire system can be increased 50 per cent by changing over to three-phase, four-wire, at a cost much below that of increasing its capacity an equal amount by the use of additional copper, there is cause for serious thought as to whether such two-phase systems should be permitted to grow. Similar conclusions can be drawn with regard to the two-phase, three-wire and the three-phase, three-wire systems. In these cases, however, the cost of the change over is a great factor, because of the necessity of running the additional wire, but in most systems it can be justified. The important factor to consider is the rapid growth of the great majority of existing systems.

"An analysis of a large system in the East indicates that the demand on its system doubles approximately every 8 yr. It is fair to assume, therefore, that even though the cost of changing over from an existing system to the three-phase, four-wire systems would be high, the present systems will be a relatively small proportion of the total system 10 or 20 yr. hence. It also follows that even assuming the cost of the additional capacity obtained by such a change is equal to or slightly more than the cost of installing an equivalent amount of additional distribution plant, once the system is changed over, the cost of additional capacity thereafter is much less per kilowatt than that for any other system.

Changing Over from Other Systems

"Notwithstanding the advantages of the three-phase, four-wire system, many companies are reluctant to change their present plant. This hesitancy is generally more pronounced in the companies operating the larger systems and is usually based upon the belief that the cost is prohibitive, and the work physically impracticable.

"A description of the program about to be started by a large eastern company, involving a distribution system having a demand of over 175,000 kv.a., may point out how such a change can be accomplished both from the practicable and financial standpoint. The system to be changed over is at present single-phase, two-wire and two-phase, four-wire and is supplied from approximately 65 substations, all of which are equipped with polyphase transformers, transforming from 13,200 v. three-phase to 2300 v. two-phase. The majority of the substations are designed to accommodate a maximum of five transformers, each transformer consisting of two single-phase Scott connected units.

"It is planned to combine the transformers in such a way that a 625-kv.a. duplex transformer will be connected to operate as a single phase unit and grouped with a 1250-kv.a. duplex transformer connected to operate as two single-phase units, thereby giving a bank of three 625-kv.a. single-phase transformers. Two banks will be placed in each substation, making a total of four transformers. Larger transformers will be used where additional capacity is necessary. To operate the present duplex transformers as single-phase units would require a minimum of six transformers in each substation, as two banks were insisted upon in order to insure service.

"In substations that require rebuilding because of crowded or overloading conditions, the new 2300-v. bus will be constructed for three-phase operation, three-pole oil switches used, the neutral being connected to its bus through a disconnecting switch and the feeders will be transferred from the two-phase bus to the new three-phase bus, as the circuits are changed over.

"In substations where no rebuilding is required the present four-pole switches operating two-phase circuits will be utilized and the two-pole switches operating single-phase circuits will either have a third pole added or will be connected to each circuit in pairs, each pair being operated by one control and one relay. Thus it will be seen that in some cases the neutral or fourth wire will be opened with the phase wire, by the oil switch; but where three-pole oil switches are used, the neutral will be connected to the bus through a disconnecting switch.

"Practically all the present power load is fed from two-phase, four-wire circuits which lend themselves admirably to three-phase, four-wire distribution. To continue to furnish two-phase service to present customers from the three-phase circuits after the change-over has been made, special 2300/4600-v. transformers with 4000 and 3450-v. taps will be used and prior to changing over the system from two to three-phase, the entire two-phase system will be retransformed, substi-

tuting the special transformers for the present standard transformers. The transformer removed will be used as the regular supply for new customers. In this way the annual requirements for transformers will not be materially increased and the only additional cost entailed is that of the special transformers and of resetting.

"The two-phase circuits will be transferred to the three-phase bus, one at a time, and it will be necessary to transfer the feeder in the substation and change the taps on all the transformers while the circuit is out of service and before it can be operated as a three-phase circuit. No difficulty is anticipated in completing this work, circuit by circuit, one day for each circuit.

"Based on operating the new system with the same phase current limit as is now the practice with the old system, which is necessary because of the large amount of underground cable in the existing plants, the capacity of the present two-phase distribution plant will be increased at least 50 per cent. The total distribution line losses will be reduced an amount which in dollars will be sufficient to pay all the carrying charges of the total cost of the change-over. While this statement is startling, it is conservative and there is every expectation that it will be realized."

Locating Switchboard Faults

SYSTEMATIC METHOD OF TESTING SIMPLIFIES PROBLEM OF DETERMINING FAULTS IN POWER PANELS. BY O. D. SMALLEY

A POWER switchboard, when installed according to the plans furnished by the manufacturer, seldom refuses to work. Switchboards, however, which have been in service for some time acquire faulty habits, the causes of which are difficult to determine unless some good method of procedure is followed. The average electrician or engineer, if called upon to investigate such trouble, finds it a long, tedious, cut and try proposition.

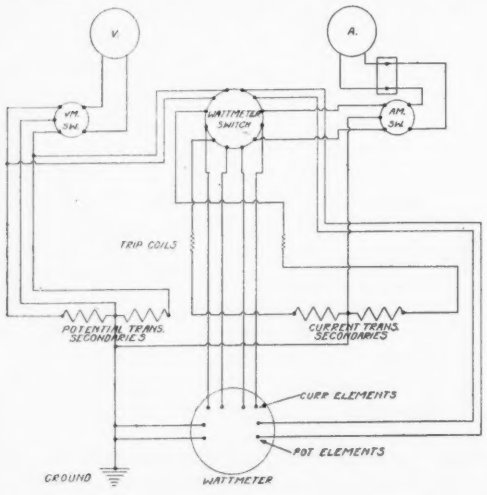


FIG. 1. USUAL WIRING SCHEME OF SECONDARY ELEMENTS IN ORDINARY POWER PANELS

The complexity of the numerous wires which might be involved serves to make the job more or less difficult, depending upon the size of the board.

On new work where commutating switches for voltmeters, ammeters, wattmeters, ground detectors and the like, are enclosed in cases exactly identical, those requiring fewer wires having dead or "dummy" terminals, there is a possibility of the face plates having been reversed thereby causing these switches to have been installed in other than their proper places. In old work where the board has been in satisfactory operation for some time before the trouble developed, this condition could, of course, not exist.

The following is a method of attacking such problems which the writer has found to be of great service in all cases of power switchboard trouble. The description is given with reference to a new board which has never operated satisfactorily, assuming the evidence of the trouble to be the failure of all or part of the instruments to register on one or more of the phases. This method will also apply in the case of old work by merely neglecting those chances for trouble which are known not to be present.

In any switchboard the heart of the system is the combination of instrument transformers which furnish the life blood (current) to the several instruments. It is ordinary practice to ground the common connection between the two current transformers and between the two potential transformers. With these connections made, it is impossible to make any sort of satisfactory tests with battery and telephone receiver (as this is the

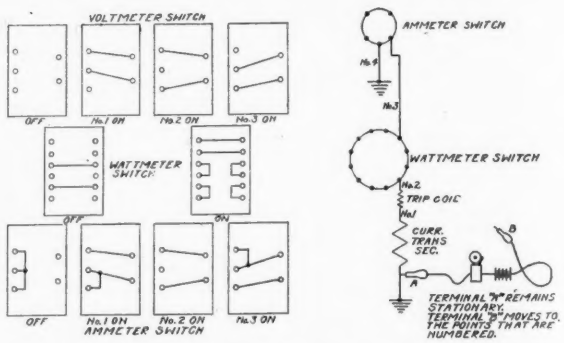


FIG. 2. DIAGRAMS SHOWING CONNECTIONS MADE AT VARIOUS PORTIONS OF THE DIFFERENT SWITCHES SHOWN IN FIG. 1

FIG. 3. SIMPLIFIED DIAGRAM OF CIRCUIT SHOWING SUCCESSIVE POSITIONS OF TEST

best test set to use) on account of the fact that there is a metallic connection between all wires of potential and current circuits either directly or through the instrument transformer windings. An open circuit or a ground can not be detected since a test buzz will be gotten either forward or backward from any particular point.

The first thing to do then is to open all connections to transformer secondaries and disconnect ground wires at all points, thus isolating each individual line from transformer through board and back to ground.

Suppose the trouble has been with the trip coils, wattmeter current coils, or any of the current circuit devices. Connect one side of the test set to one lead from one current transformer secondary (not the lead that went to neutral ground, but the one that takes the board circuit). With the other side of the test set, follow this

lead along in successive steps, as indicated in Fig. 3, until a buzz fails to result. At each step, take in one more element of the board in the order at which they are arrived. The first step will probably be just through the trip coil in that lead. If this tests O. K., take another step which will include the wattmeter switch. This should give test buzz with switch in "off" or any of the three "on" positions. In case no trouble has yet developed, proceed so as to include the ammeter switch. This should also give the test buzz with any position of the switch due to the fact that in any position of current switches the current circuit must be completed either through the instrument when "on" or through the switch when "off." On including the ammeter switch, the circuit should be complete, bringing up at the point where the ground wire was disconnected at the outset.

If at any of these successive positions the test fails, the trouble must be an open in the switch if in the "off" position as regards that phase, or in the switch or instrument and its leads to switch if in the "on" position as regards that phase. The same process may then be repeated for the circuit leading from the other current transformer. If the trouble is reached at some particular switch when in the "on" position, the investigation must be carried further to ascertain whether the trouble is in the switch, instrument, or leads from the switch to the instrument. If a shorting of the terminals of the instrument gives the test buzz at the point of trouble, the open is in the instrument; if not, the open is in the switch or the leads from the switch to the instrument.

If no test failure is encountered, the trouble must be a short rather than an open and the process should be repeated with the instrument coils disconnected. In this case, the trouble is reached when a buzz is obtained with switch in the "on" position for that phase and the instrument disconnected.

In testing the potential circuits, the same procedure is followed except that in this case the buzz should test only when the switch is in the "on" position if things are right. Here an open circuit only can be expected unless the instrument fuses blow when the trouble is present.

In testing the potential circuits, the fuses should be removed and jumpers inserted in their places, as the current of the test set is apt to damage them.

Needless to say, any trouble of this nature on a switchboard should be attended to as soon as possible. Previous to the time a thorough inspection can be made, care should be taken not to leave a current switch in an "on" position which fails to cause an instrument to function, owing to the fact that an open in the secondary of a current transformer causes a potential both dangerous and destructive.

THE BUREAU OF MINES has undertaken, at the Pittsburgh Experiment Station, an investigation of the mechanism of scale formation in steam boilers. The object of the investigation is to determine if the character of the precipitates forming in boilers may be made to assume a form in which they do not attach themselves to the walls, and also to ascertain if the material in the boiler wall exercises any influence. The work will be done in co-operation with a company manufacturing combustion appliances, which will bear all expenses.

Superpower System for Japan

BY C. A. POWEL

DEVELOPMENTS IN Japan within recent months indicate the future possibility of a superpower system to furnish electricity over the large area between Tokyo and Osaka. The completion of the contemplated program will give this Far Eastern nation one of the largest, if not the largest, superpower systems in the world.

The principal industries in Japan are situated along the south coast of the Island of Nippon, the largest island of the Japanese group, and more especially around Tokyo and Osaka, and, to a lesser degree, Nagoya. To the north of Nagoya and approximately halfway between Osaka and Tokyo, the rough and somewhat sparsely populated provinces of Shinano and Mino are particularly rich in water power, which is capable of development at such a cost as to make transmission to both Osaka and Tokyo an economical proposition.

The chief rivers in this district are the Kiso and Tenryu Rivers flowing south into the Pacific Ocean and the Shinano River flowing north into the Sea of Japan. These rivers, especially the Kiso and its tributaries, have already been utilized for power purposes to a certain extent, but it is planned to obtain from them within the next few years an additional half million kilowatts.

The topography of the country and the natural resources in this district are conducive to the construction of a superpower system and the leaders in Japanese industrial life realize this fact as has been evidenced by the formation of the Daido (Great United) Electric Power Co., which has recently come into prominence through large orders for electrical machinery placed in the United States.

The prevailing frequency in the Tokyo district is 50 cycles and in the Osaka district 60 cycles, so that stations built to supply power to one district cannot readily supply it also to the other. An interchange of power is, therefore, at the present time not possible; but it is more than probable that the power companies serving the two territories will find it to their advantage, as their load increases, to arrange for some interchange of power. The Daido Electric Power Co. is building the Momoyama Station with this possibility in view, the generators, transformers and switchgear being ordered for service at both 60 and 50 cycles, and it is assumed that the future developments of this concern on the Tenryu River will be built along the same lines. This superpower scheme, when realized, will cover practically the whole of central Japan and will be one of the largest in the world.

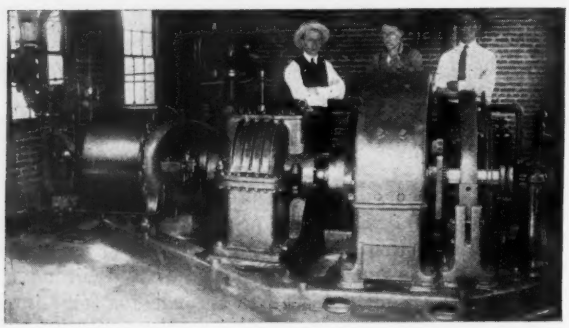
The electric power companies are all taking part in a development of water power resources which is probably without precedent in the history of engineering. From January, 1920, to June, 1921, Japan ordered abroad hydroelectric machinery totaling 260,000 hp. and in the same period manufactured at home 150,000 hp. of such machinery. Later figures are not available, but indications are that the development since has been more rapid.

MAKE SURE the prize you chase is worth the price.—Forbes Magazine.

Powder Company Installs Small Condensing Turbine

SAVINGS of about $4800 a year in coal are among the claims made for the new power equipment recently installed at the Marlow, Tenn., plant of the Hercules Powder Co., according to the "Hercules Mixer," the employe's house organ. The new equipment consists of a steam turbine, driving a 250-v. direct current generator, the set being rated at 300 kw. or 400 hp. The former equipment consisted of two 250-v. direct current generators driven by belts from horizontal high speed engines. The result of an investigation into the steam economy of that equipment, with especial regard to a contemplated increase in the plant's capacity, and taking the increased price of coal into consideration, convinced the engineering department of the Hercules Co. that a modern generating plant was necessary. They found that the steam consumption of the old units was excessive, amounting to about 55 lb. of steam per kw.-hr. The new outfit requires only 30 lb. of steam per kw.-hr., or a saving of nearly half the total steam. Tests also showed that with the former equipment, the contemplated increase in the plant's capacity could not be accomplished without the addition of another electrical unit, and even then, the steam consumption of the engines was such that another boiler would be necessary.

Besides these there were other considerations that had a decided influence on the solution of the problem.



NEW GENERATING UNIT IN HERCULES POWDER CO.'S POWER PLANT

The old power plant had a coal trestle on one side, and a shale bank on the other, requiring careful study to avoid interference with the existing coal handling layout, and to eliminate a large amount of difficult excavation for the new unit. Secondly, there was no large natural water supply near the power house, necessitating provision for the artificial cooling of the condenser water. The auxiliary steam driven units provided sufficient steam to heat the boiler feed water to over 200 deg. There was also the probability of having to operate the plant while the new equipment was being installed.

From the economic side, the boilers and engines are operated by one man per shift, and in order to avoid an increase in the operating force it was necessary that the new installation be at least as simple in operation as the old. The choice of the turbine, then, was determined by its more economical operation, lower initial cost, smaller floor space required, and the low cost of maintenance as compared with that of an engine.

The new power house was built to the south of the old engine room, and has two levels, the condenser floor being on the same level as the old engine room, and the turbine floor about 10 ft. higher, the space above the condenser floor being open to the roof. This arrangement conforms to the bank at this point, and required no excavation below the turbine. The steam turbine drives the 250-v. direct current generator through a set of gears which reduce the speed from 3600 r.p.m. at the turbine to 1200 at the generator. The turbine, gears, and generator are mounted on a single cast-iron bed plate, and rest on a solid concrete foundation 5 ft. deep. The turbine operates at 110 lb. pressure at the high pressure end, exhausting into a condenser at 28 in. vacuum.

Condenser water is cooled in a spray pond about 200 ft. from the power house, located in a natural depression in the ground which only required clearing and leveling. Water is carried in an 8-in. pipe of cast iron to the spray nozzles above the pond, from which it issues in a finely divided spray, falling back into the pond and returning through a cast-iron pipe to the cold well near the power house, whence it is drawn into the condenser by vacuum.

The new unit, which was furnished by the General Electric Co., is arranged so that it may be operated independently of the old engines. A switchboard is located in the new building near the turbine, and is directly connected to the distributing board in the old engine room. The arrangement is such that both the boilers, the turbine, and the condensing unit may be easily operated by one man, and the actual work of operating has decreased, since the smaller steam consumption required less coal being fired. It is expected that the savings of the turbines will be greatly increased when the capacity of the plant is increased due to the higher economy of the turbine at greater power load.

Rust Tests of Sheet Steel Containing Copper

By J. H. Blakey

THE REVUE DE METALLURGIE for September sums up an article by M. O. Bauer on this subject which appeared in Stahl und Eisen. The tests were made by the State Bureau for Testing Materials at Berlin-Lichterfelde, Germany, to verify an assertion which appeared in the Iron Age, according to which an addition of about 0.3 per cent of copper in the manufacture of a soft steel will retard considerably the appearance of rust on a plate of this material when exposed to the air.

The conclusions reached are as follows: With plates exposed to the air or buried, the presence of the copper has an effect only if the surrounding medium is acid; with plates plunged in water, the influence of the copper is appreciable only when the water is saturated with CO_2; the presence of the copper gives protection against the attack of sulphuric acid, and phosphorus contained in the metal considerably favors this attack.

IT'S ESPECIALLY hard to be a good loser if you never win anything.

Trouble Hunting---XVI

MAKING THE JUNK HEAP PAY DIVIDENDS. BY JOHN PIERCE

I HAD to dig around quite a bit in the mess of junk before finally unearthing an old duplex pump that never looked as if I could fashion a pump from its remains. I persisted, however, and got the cylinders and frame. There was one piston, piston rod, and part of the plunger. We cut out the liners and knocked out the spiders and cleaned her all out. The steam cylinders were in good shape and needed only to be brushed up somewhat with emery cloth. We were lucky enough to find a set of liners of the right diameter and fit, except being 2 in. too long, so it was not a very large job to cut them off. We had to turn out the plungers and follower plates from old castings, as well as the pistons. Finding some old brass rods that formerly had belonged to Cameron "sinkers," we made a dandy pair of rods. Then we bushed up the rocker arms, and the saddle. Next we took off the steam valve chest cover and were a little disappointed in what we found.

The valve was in fair shape but one of the ports was rusted off at the corners completely and partly so in other places. The valve did not reach the end of the hole made by rusting, even at its extreme travel. There seemed, at first, no manner in which it could be remedied; but we dressed the valve on that end, and fashioned a plate which was quite satisfactory, but which made the valve considerably longer on that end than it should be. We then cut away the part the exact amount that we had added on the valve, chipped down the valve seat so the valve would not strike when on that end, and our pump was as good as new.

We then took three tanks, each of 8000 gal. capacity, and put them on the upper side of our storage water tanks, at the bottom of which we put a 4-in. gate valve and a drain pipe. Eighteen inches from the bottom we put a 2-in. pipe that reached clear across the tank and was fastened on the far side with a flange, and the other end was left sticking through the tank. Of course we put a gate valve there in order to control the water. In the upper side of this 2-in. pipe we drilled hundreds of small holes, but only on the top. Then we laid our pipe line from the pump to the tank, with pipe which we had dug up when we changed the steam line to the oil pump.

We tried our treating system. It was certainly awful to see the stuff we "threw down" in those tanks. We pumped them full, then threw in the proper amount of carbide, which was most expensive, and as soon as this had settled we threw in the Perolin. We tried to do this each day in time so we would have finished by four in the evening. At three in the morning, the night head fireman would open the 2-in. valves, and at seven the good water would be all out down to the pipe. This valve would then be closed and the drain opened. Such stuff as came out was a sight to see. Of course we did not intend to use this treatment longer than was necessary on account of the cost; but at that time it was cheaper to use it, or so we felt, than to shut down waiting for water from the springs.

The next thing was to fix an oil reservoir at the boilers. My predecessor had mounted a 500-gal. tank there when he was preparing to cool boilers for washing, but he had stood it on end, leaving the top open, and as it was only 3 ft. in diameter it filled up pretty fast—when the pump would work. The pumper was about 400 ft. away with his pump, and he had this tank running over half the time. My predecessor had built a coil of 1-in.—I think it was one, though it may have been three-quarters—pipe, consisting of about 20 ft. in all. This was set in the tank, resting on the bottom, and came out through another piece of pipe screwed into it, while enough of the original 20 ft. was left uncoiled to reach the top of itself. This, with its valve wide open, would not heat the oil so it would run to the oil pump fast enough to fire the boilers. There was a heater between the pump and the boilers equipped with a coil, which also used lots of live steam.

I changed this evil by setting two wooden tanks, making it only a temporary job, above the boiler room about 25 ft. higher up the hill. I ran a 4-in. pipe, well covered, from them to the feed pump, and through this pipe I ran a 1-in. pipe and sent the exhaust from the pump through it. I had to put on a tee at the last turn and with bushing made a stuffing-box to let my pipe out. This kept the oil warm enough to flow readily to the pump, allowing me to take the small steel tank down. Each of these tanks held enough to run 48 hr. and we used from them 24 hr. alternately. By putting in floats and markers, with a lamp for the night, the pump man could not only see them clearly and so govern his pump, but we could keep an accurate measure on the oil used. I sure was well pleased with myself when I had finished this job.

The heater between the pumps and boilers was the next problem as we felt that the exhaust steam from the feed pumps could be used quite nicely for this purpose. It was only a small job to bring it around to the heater and make the change with most gratifying results. The exhaust from the feed pumps and the fuel pumps had been going into the atmosphere up to this time, and the live steam used for the same purpose was something awful. At the oil pump station the pump stood out in the weather, and the exhaust went to waste while the 6-in. suction line was warmed by having a hole tapped into it near the tank and a ½-in. pipe screwed into it. Then live steam was turned on and the oil partly heated in this way. The pump would struggle and buck, and did not work well at all.

We got busy and built a pump house and I hunted up another pump and connected it up. This pump was not hard to fix up since it had been thrown aside before the revolution and the rebels had not bothered it any. It was nearly "all there" and the parts we needed were found in stock. I made inquiries from the old men, and found it had been thrown aside because it could not be depended on, as it would not hold its gaskets between the valve chambers. Opening it up, I found a cross rib 1 in. wide between the chambers that had been eaten and rusted off until it was round on the corners and smooth. At spots it was low, and the gasket,

once put in, would stay only a few strokes and then go out.

I had the boys bring me a roundnose chisel and we cut a groove ⅜ in. wide and nearly ¼ in. deep along the center of the rib. I then took sheet lead and laid it in the groove until it stuck up just a fraction above the rib. Cutting the gasket, we laid it in place, and, as we brought the upper valve plate down, hammered it with a mallet until we had a good fit.

This ended the trouble with the pump, and as it was a 3-in. "Knowles," I found I had a very good and dependable sister in her. Once she was connected up, I had the boys bring in the former oil pump and set her up alongside old lady Knowles, giving us a two-unit station. The half-inch line was cut loose from the suction and a 2-in. pipe run through it for its entire length, coming out where the pipe joined the tank, and connected to the exhaust of the pumps. This ended the bucking and jumping of the pumps, and gave me oil hot enough so that it could be pumped nicely, and the live steam saved. The men were well pleased also, as we had built our pump house large enough so that the pumpers could all have lockers, a bench, and tool lockers. This gave them a place for keeping their clothing and other things, as well as a shelter. I was told that in all the years the place had been operated, this was the first time any effort had ever been made to do anything for the men; that houses and shops had been built to protect the machinery, but never to keep the men in from the cold or wet.

By now we had got the water down to the 430-ft. level, and our boilers began to show signs of quitting us, for as we went down with the water, we had built up our pressure on the air lift to 120 lb., and having added on a steam engine of 15 hp. in our machine shop, rigged up an engine from the junk heap and set it working at a sawmill connected with the carpenter shop, and tied all the pumps on the boilers, the four old sisters were pretty well loaded. Had we been able to handle the compressor without the 2-in. booster cut into the low-pressure side, we'd have been all right; but this was a necessity, and had to be done. By now I had the "gallows frame," or, as it is more commonly called, the "head frame," all framed and ready to start putting up, as we began to tear down the old one which was in a bad condition.

In the meantime I had sorted out of the junk heap another Westinghouse high-speed engine and proceeded to mount her on a brand new foundation. I had considerable trouble in finding the governor wheel to this engine, as it was not in the heap of junk any place. Finally I found it down in the city where some enterprising hombre had taken the trouble to haul it. What on earth he ever intended to do with it nobody will ever know; the reason I am sure of this is that he only shrugged his shoulders when asked what he intended doing with it, and that night he was stabbed to death. The generator had not been harmed, so we finished the engine and turned her over a few times, and set up the generator. Wire was something I could not find in the junk heap, and that we had to bring in from the States.

Until then I had managed to do all the refitting and rebuilding from this heap of old material, and had purchased but little except tools and packing. I found an old leather belt, but it was so rotten I was afraid to use it, so I ordered, or rather, made requisition for a new leather belt. When it came, it proved to be a canvas belt, and before I knew it the men had put it on and clamped the ends together with heavy steel belt hooks. Going over the pulleys it made a terrific noise and jarred the generator badly. I was afraid of a bent shaft, for my belt centers were very short and the belt had to be run tight. The natives eyes sure popped out when I was trying out the generator, as lots of them had never seen electric lights before and they were much puzzled as to why we got light when there was apparently none to be seen in the generator.

Industrial Machinery Export

AN INDUSTRIAL Machinery Division has recently been organized in the Bureau of Foreign and Domestic Commerce to promote foreign trade in such machinery. The output of the 4000 factories making these machines in 1919 exceeded $2,200,000,000 in value, of which $400,000,000 worth was exported. Of the exported machinery the percentages used for power plant and equipment purposes were as follows: Air compressors, 6.5; elevators and machinery, 4.8; engines, 10.4; pumps and pumping machinery, 13.9; refrigeration, 7.1. This does not include electrical machinery which is handled by the Electrical Division of the Bureau.

The Industrial Machinery Division aims to be of the greatest possible service to manufacturers, and will establish close contact with firms seeking export trade as well as with conditions in foreign countries. The object is to help manufacturers solve their various problems as to the wisest method of selling, available agents and their qualifications, development of new business and of engineering enterprises. Firms wishing to receive information along these lines should send request to be placed on the Bureau's "Exporters' Index," to the Industrial Machinery Division.

Several important reports have recently been published in Commerce Reports regarding railway cars, locomotives, machine tools, German and British competition, etc., and others are in preparation including a summary of regulations of all foreign countries covering inspection, construction and operation of steam boilers, air containers and electrical machinery. Also reports concerning steam and hydraulic stations of the world, prospective extensions and construction of railroads and highways and the outlook for marketing automobiles and trucks.

The division desires the advice of manufacturers as to matter and method for collecting information so that it may be of definite value to those engaged in the machinery industry, and as to the best ways of getting contact with manufacturers so that the information gathered may be made most widely and effectively useful to them.

Pipe Treatment

AN OLD engineer said that brown shellac mixed with graphite makes an admirable cement for pipe and connections which are subjected to heat and compression. The two ingredients should be mixed to a paste and smeared over the joints needing treatment.

J. B. DILLON.

The Relation Between CO_2 and Stack Losses

THE MAGNITUDE OF THE CHIMNEY LOSS BEARS A DEFINITE RELATION TO THE PERCENTAGE OF CO_2 IN THE FLUE GASES

IN THE PROCESS of producing steam in a boiler or in any other operation involving the combustion of fuel, the most important factor affecting efficiency is the heat escaping to waste up the chimney. In ordinary practice this heat loss ranges from 15 to 50 per cent of the heat contained in the fuel.

Through the courtesy of the Uehling Instrument Company we have been furnished with data upon which this article is based which explains fully the various factors governing the chimney loss and shows the relation which the percentage of CO_2 bears to the money wasted up the stack.

Figure 1 reproduced from a government bulletin shows the great importance of the chimney loss as compared with the other boiler losses and in Fig. 2 taken from the same bulletin are shown the possibilities of improving the efficiency, principally by reducing the chimney loss. In the average boiler plant, according to the Bureau of Mines, 35 per cent of the heat in the coal burned under the boilers is lost with the stack gases.

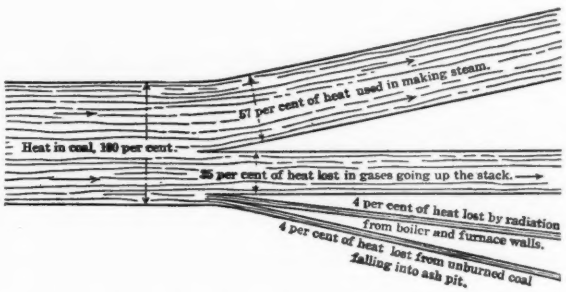

57 per cent of heat used in making steam.
Heat in coal, 100 per cent.
35 per cent of heat lost in gases going up the stack.
4 per cent of heat lost by radiation from boiler and furnace walls.
4 per cent of heat lost from unburned coal falling into ash pit.

FIG. 1. WHERE THE HEAT GOES IN THE AVERAGE BOILER PLANT

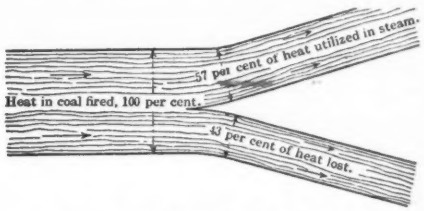
That is, out of every 100 T. of coal burned under the boilers, the heat of 35 T. literally goes up the stack. This loss can be greatly reduced and every effort should be made to do so.

The magnitude of this loss bears a definite relation to the percentage of carbon dioxide in the flue gases as shown by Table I which covers the principal fuels. The losses listed in this table include the heat in dry gases resulting from combustion of carbon as well as heat in vapor resulting from combustion of hydrogen. The reference letters (a), (b), (c), etc., refer to the composition of the fuels given in percentage as follows: (a) 84 C, 2.8 H, 3.2 O, 10 Ash; (b) 70 C, 5.5 H, 14.5 O, 10 Ash; (c) 85 C; 12 H, 3 O; (d) 62.7 CH_4, 20.2 C_2H_6, 15.5 CO_2, 0.2 O, 1.4 N; (e) 76 CH_4 16 H, 5 C_2H_6 1 O, 2 N; (f) 50 H, 35 CH_4, 6 CO, 2.5 C_2H_4, 2 CO_2, 0.5 O, 4 N; (g) 18 CO, 12.5 H, 2.2 CH_4, 0.2 C_2H_4, 9 CO_2, 0.1 O, 58 N; (h) 27.5 CO, 2.5 H, 11 CO_2, 59 N.

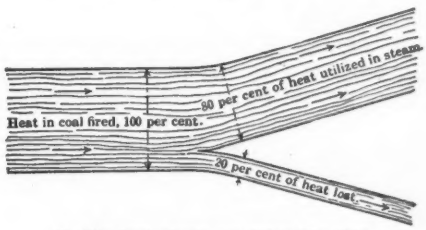
In all commercial fuels the principal combustible element is carbon. The only other important combustible element is hydrogen, existing either in the free state or combined with carbon in the form of hydrocarbon.

RELATION BETWEEN CO_2 AND PER CENT FUEL LOSS

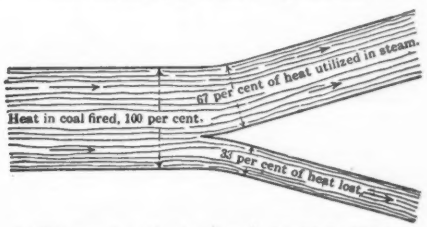
A MOST IMPORTANT fact in connection with CO_2 determinations is that a definite relation exists between the percentage of the fuel lost up the chimney and the percentage of CO_2, no matter what the percentage of available hydrogen may be. Furthermore, considerable variation in the composition of the fuel will not materially



A. The average boiler plant does like this.



B. The best plants are doing like this.



C. The average plant can and should do like this.

FIG. 2. DIAGRAMS SHOWING POSSIBLE IMPROVEMENTS IN EFFICIENCY AT AVERAGE BOILER PLANTS

change the amount of chimney loss corresponding to any given percentage of CO_2. This fact is clearly illustrated by columns 3 and 4 of Table I which shows that the losses for anthracite and bituminous coal are practically the same for any percentage of CO_2 even though the bituminous coal contains considerably more hydrogen than anthracite.

Hydrogen in the fuel does, however, have an influence on the maximum attainable percentage of CO_2 and it will be noted from Table I that as the percentage of available hydrogen increases the maximum attainable percentage of CO_2 decreases.

The figures given in the table are based on 75 deg. F. boiler room temperature and what is considered average flue gas temperature, viz. 575 deg. F. The figures include the total heat contained in the chimney gases; these gases consist of the carbon dioxide (CO_2) resulting from the combustion of carbon, water vapor or steam (H_2O) resulting from the combustion of hydrogen, (if any), and the remaining gases such as nitrogen and oxygen. The figures for losses do not, however, include

such minor losses as those due to the evaporation of the moisture in the fuels and unburned combustible material escaping up the chimney because the latter losses are insignificant by comparison.

It will be noted from the table that the lower the percentage of CO_2 the greater will be the gain corresponding with each per cent increase in CO_2; also that the losses increase at an alarming rate at low percentage of CO_2.

TABLE I—PER CENT LOSS UP THE CHIMNEY FOR VARIOUS FUELS

Per Cent CO_2	Carbon (Coke Charcoal Wood Dry Fuel) Regular	Anthracite Coal a Lump Pea	Bituminous Coal b	Fuel Oil c	Natural Gas (Calif.) d	Natural Gas (Penn.) e	Coke Oven Gas f	Producer Gas g	Blast Furnace Gas h	Per Cent CO_2
	Loss	Loss	Loss	Loss	Loss	Loss	Loss	Loss	Loss	
21	10.3								20.4	21
20	10.8								21.3	20
19.5		11.6								
19	11.3	12.1							22.3	19
18.6			12.8							18.1
18	11.9	12.6	13.1					21.4	23.4	18
17	12.6	13.2	13.6					22.2	24.6	17
16	13.3	13.9	14.2					23.0	25.9	16
15.7				11.3						
15	14.1	14.6	14.9	11.7				23.9	27.4	15
14	15.0	15.4	15.6	10.4				25.0	29.2	14
					20.0					13.8
13	16.1	16.4	16.5	17.1	20.5			26.2	31.3	13
12	17.4	17.5	17.6	17.9	21.2			27.6	33.6	12
11.5						20.3				11.5
11	18.9	18.9	18.8	18.8	22.0	20.7		29.3	36.4	11
10.7							20.7			10.7
10	20.7	20.5	20.3	19.9	23.0	21.5	21.2	31.2	39.8	10
9	22.9	22.6	22.1	21.4	24.2	22.6	22.1	33.7	43.9	9
8	25.8	24.9	24.3	23.1	25.8	23.7	23.1	36.7	49.1	8
7	29.3	28.1	27.2	25.3	27.8	25.2	24.5	40.6	55.6	7
6	34.0	32.3	31.1	28.4	30.4	27.3	26.3	45.8	64.5	6
5	40.7	38.3	36.5	32.6	34.1	30.3	28.9	53.1		5
4	50.1	47.1	44.6	38.9	39.6	34.7	32.8			4
3	67.2	61.8	58.1	49.4	48.9	42.0	39.2			3
2					67.4	56.7	52.0			2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

TABLE II—EXAMPLE IN FUEL SAVING BY INCREASING CO_2

	1st Case	2nd Case
CO_2	6¼%	10%
Chimney Loss (From Col. 4 Table 1)	30%	20%
All Other Losses....See footnote page 5	10%	10%
Total Loss	40%	30%
Efficiency (100 – Total Loss)	60%	70%
B. T. U. per lb. of fuel	14,000	14,000
B. T. U. converted into steam per 1,000 lb. of fuel (1,000 x 14,000 x efficiency)	8,400,000	9,800,000
Relative weights of fuel to produce same amount of Steam 1,000 x 14,000 x 60% = 8,400,000 B. T. U. 857 x 14,000 x 70% = 8,400,000 B. T. U.	1,000 lb.	857(+)lb.
Saving in pounds per 1,000 lb. Fuel Purchased		143 lb.
Saving in per cent		14.3%
Saving in Dollars per $1,000 spent for Fuel		$143

An Example in Fuel Saving by Improving CO_2

While the table shows accurately what percentage of the total heat available in the fuel is wasted up the chimney, it does not bring out clearly the full extent of the fuel savings that may be accomplished in increasing the percentage of CO_2. These are actually much greater than is generally realized. The following illustration will make this point clear.

Assume the case of a boiler burning bituminous coal having a heat value of 14,000 B.t.u. per lb. as fired.

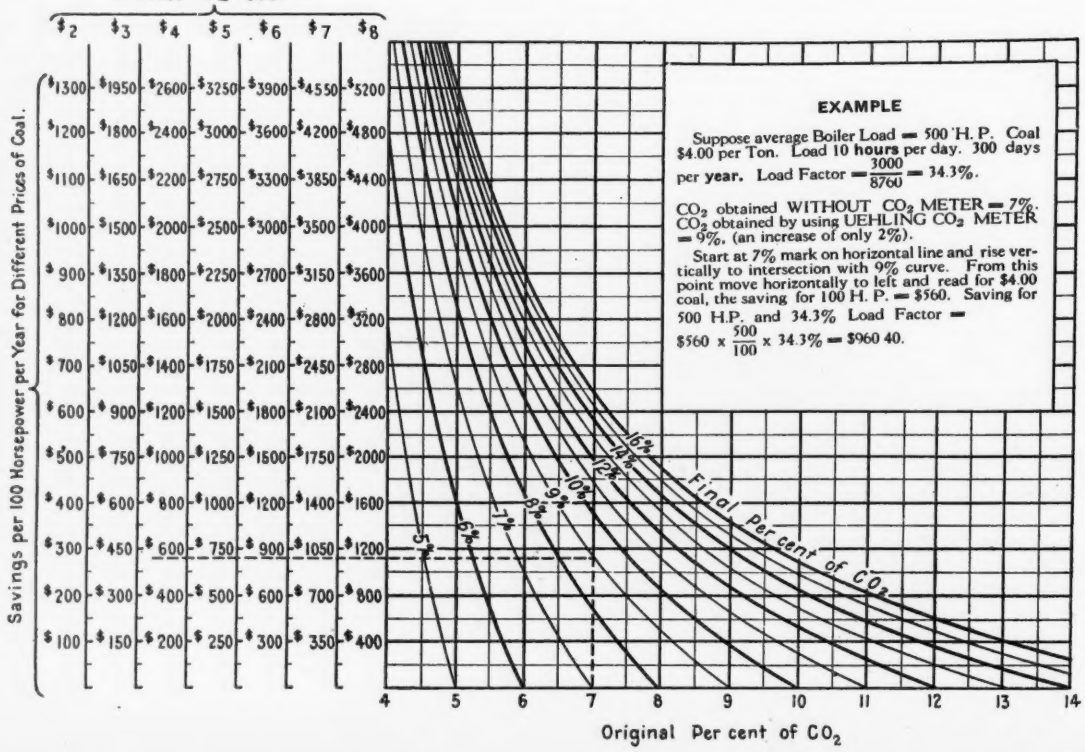


FIG. 3. CHART SHOWING SAVINGS OBTAINED BY INCREASING PERCENTAGE OF CO_2

Also that at first the percentage of CO_2 is 6¼ per cent and later, with the aid of suitable recording equipment, it is improved to 10 per cent. Assume further that all other boiler losses exclusive of chimney loss equal 10 per cent in each case. Then from the table the losses would be as shown in Table II, from which the savings in the second case are calculated as shown.

From this example it will be observed that, although the chimney loss is reduced only 10 per cent (that is, from 30 to 20 per cent) by increasing the percentage of CO_2 the actual reduction in fuel consumed amounts to 14.3 per cent, a cash saving of $143 on every $1000 spent for fuel.

The chart shown in Fig. 3 may be used for determining the savings in dollars per boiler horsepower which may be effected by increasing the percentage of CO_2. Suppose for instance that the original per cent of CO_2 is 7 and that after improving operation the average CO_2 is increased to 9 per cent. Starting at 7 per cent on the horizontal or base line of this chart and rising to the 9 per cent curve and then running over horizontally to the left, we find that with $4.00 the increase of CO_2 means a yearly saving of $560. This, of course, is for 100 boiler horsepower operating continuously. If the load factor, instead of being 100 per cent, were, for example, only 33⅓ per cent, that is, if the boiler were kept in operation only 8 hr. per day instead of 24 hr. then the saving would be one-third of $560 or $186.67 per boiler horsepower and for a 500 hp. boiler 5 × $186.67 = $933.35.

This is the saving obtained by an increase in CO_2 of only two per cent. In many plants it can be increased 6 or 7 per cent without great difficulty with a correspondingly greater saving. Even though the CO_2 be increased only one per cent, the savings would still fully warrant the investment incurred in the installation of suitable instruments for determining the efficiency of combustion.

Improving Operation of Ft. Sill Plant

NUMEROUS MINOR CHANGES AND REPLACEMENTS REDUCE FUEL EXPENSE $1200 PER MONTH. BY WALTER J. STEWART

IN OUR endeavor, during the past 4 yr., to build up the Ft. Sill, Okla., plant, we naturally turn first to the boiler room. On our four 150-hp. B. & W.'s we have installed new baffle walls. The old deteriorated tile baffles were replaced with monolithic baffle walls at a cost of about $1200, and their effectiveness and lasting qualities are fully up to our highest expectations. The boiler blowoff valves were also in bad shape and were replaced with seatless blowoff valves, and these have no doubt paid for themselves through the stopping of all leakage at this point.

We were fortunate in securing a centrifugal boiler feed pump. This is an eight-stage pump driven by a 15-hp. steam turbine, which is controlled by an overspeed and an excess pressure governor. This unit has been in continuous operation since January, 1920, and has only been stopped three or four times for a few minutes to repack the shaft boxes. Its operation is so smooth that numerous visitors have asked if it were running. The flow of water is so steady and sure that a great load is taken from the firemen's shoulders, and all feed line vibration and the slamming of check valves has been eliminated.

The little duplex outside packed pumps formerly used for boiler feed, are kept in readiness, but never used except at short intervals or for running the Lagonda tube cleaner. The saving in labor and packing, since the centrifugal pump was installed, has been considerable; also the steam consumption of the driving turbine is probably less than one-half that of the old direct acting pumps.

At the same time that the new feed pump was installed, we also put in a Venturi meter on the boiler feed line. This meter is of the graphic recording, integrating and indicating type, and, needless to say, not only gives the fireman a chance to strive for an even flow rate, but gives us a very good check on our evaporation when considered in connection with the fuel oil meter.

During the war emergency, two 150-hp. return tubular boilers were installed in the "future" space next to the B. & W.'s. This seemed like an almost criminal offense, but we were told that B. & W.'s could not be had as they were all needed for the new ships.

We had considerable trouble with leakage at the girth seams on these boilers, but finally got them tight and installed girth seam protection tiles to keep the intense heat of the oil flame away from the rivets. Now they are giving good service except that they require careful and periodical cleaning much oftener than the B. & W.'s.

We use boiler graphite to keep down scale, and find it very effective. Of course the scale forms just the same, but in the B. & W.'s the rapid circulation loosens it from the tubes when about at thick as egg shell, carries it to the boiler blowoff drums, and we get rid of it there. The blowoff lines near the boilers show evidence of scouring from the scale and sediment blown off, and require occasional renewals.

At the time the two new boilers were installed, a 6-in. steam main was put in to supply steam to the new laundry about 500 ft. distant. This work was not designed locally, so we wondered why such a large line was necessary. It looked as if we would have to get up and step, if they ever opened up on the other end. The construction company finally completed the job, and its operation was like this: Steam at 135 lb. was taken from the plant to the laundry in a 6-in. main supported on wooden poles, and there reduced to 90 to 100 lb. for the laundry equipment, and to 2 to 5 lb. for the heating system.

The reduced pressure steam for both purposes went into 3-in. pipe, so it will readily be seen that the 6-in. main was very much in excess of the requirements. The 6-in. main was "covered but not insulated" as the insulation salesman expressed it, and all the piping in the laundry was not even covered. The reducing valve for the 135 to 90-lb. reduction had the same size diaphragm as the one for the low pressure heating service, and then they wondered why they could not hang

weights enough on it to get the right working pressure. I was going to suggest some car wheels for the job, but happened to think that the lever arm wouldn't stand it, so kept silent. Finally the reducing valve was abandoned and hand regulation resorted to, with the result that the laundry equipment was subjected to nearly full boiler pressure most of the time.

They also put in two 2-in. return lines to carry the condensate back to the plant. One of these was the vacuum return line from the radiators, and connected with the vacuum pump in boiler room of plant. The other was the high pressure return from the laundry equipment, or rather was part of the high pressure system, as the trap for handling this condensate was also in the plant, a good 500 ft. distant from the nearest machine to be drained.

Both returns were laid in the ground, with only a single wrapping of tar paper on them. I suppose they figured that if we got the water back, that would be enough. As for any lost heat, what would a few more B.t.u. more or less amount to, anyway? Then, too, there was a nice little expensive expansion joint on each of these lines, about in the middle of the run, with a concrete box and steel cover to make them accessible. The pipes where they entered the box were cemented in solid, presumably so they could not move too much and overwork the expansion joint. As a matter of fact, no expansion ever took place in the joints, but rather almost anywhere else along the line, where numerous leaks and broken fittings would develop from time to time.

The return lines in the laundry were also laid in the ground, and covered with a 4-in. concrete and wood floor. No provisions for expansion or accessibility were made, and no attempt made at insulation. The result was that the floor was very hot to stand on in some places, and plenty of leaks developed from time to time after the system was put in operation. In each case it was necessary to tear up a lot of floor to make the repair. In short, the operation of the whole thing was so faulty and wasteful that we immediately put up a howl for an appropriation to correct it.

After about 6 mo. delay, the proposed changes were approved. A new 3-in. steam main and two 2-in. returns were installed in a concrete trench from the plant to laundry. Individual traps of the proper sizes were put in to serve the machines, the return lines under the floor were abandoned, and a new overhead return line installed in the building proper to connect with the line in the trench. The large trap in the plant was, of course, then removed, thus eliminating the steam which formerly had to come back in this line to operate the trap, and reducing the pressure in the line to just the few pounds necessary to lift the condensate into the open heater.

During the first months of operation after the above changes were made we found we had saved nearly $1200 on fuel alone, to say nothing of the heavy repairs and interruptions formerly necessary. This saving would not have been quite so great but for the fact that the 6-in. main had some bad leaks; however, we can claim that over half that amount has been saved monthly since the changes were made, by better insulation, practically no leaks, and the more efficient manner in which the traps are installed. There are still some details on this project which offer chance for further improvements, and these we have in mind to perform as soon as opportunity and money are afforded.

To get back to the equipment in the plant proper, just at this time we have had a little trouble with the turbine driving the boiler feed pump. We found the stationary blading between the two rows of revolving blades to be badly cut out, and are ordering a new piece for this, and at the same time are going to make a new steam connection for this machine at a point where we will get dry steam.

This plant supplies heat to a part of the post by an Evans Almirall system of hot water heating by forced circulation. The water is heated by an exhaust steam heater during mild weather, supplemented by a live steam heater in colder weather. Last season it was necessary to use somewhat more live steam than should have been required, due to an accumulation of scale on the heater tube surfaces. There was no chance to clean these heaters by mechanical means, so it was done with chemicals, using a small pump to circulate the same. We are now certain that all our exhaust is being condensed before we have to use any live steam, and also that the live steam heater is working at its proper efficiency.

The ice-making and refrigeration department of the plant is also deserving of some mention. The compressor is a 20-T. York vertical, driven by a horizontal Corliss engine. Several years ago this machine met with a mishap to the steam piston. The follower plate broke and fell down in the cylinder and the steam rod was bent so badly that it had to be sawed up in pieces to remove it. New parts were put in but the steam crank bearing would not behave and gave lots of trouble. The machine was operated, however, for a couple of years in this condition, when it was finally discovered that the main shaft was cracked and sprung where the crank was fitted on.

A new shaft was ordered and installed and the machine carefully lined up throughout. The 25 or 30 individual oil cups were replaced by a gravity feed oiling system of sight feed devices piped to a common supply tank.

Our ice output (6 T. daily) does not supply the demand during the hot months, and yet the compressor is not being worked to capacity. We sought to correct this by trying to get funds to change the ice cans from 200 lb. to 300 lb., as the tank is built to accommodate the latter size can if desired, and to install a suitable brine agitator (we now have none) to help cut down the hours of freezing. This would have given us a full gas load for the compressor, and increased our ice output to approximately 10 T. daily, leaving a sufficient margin to carry the small cold storage rooms.

The proposed change would have been a most economical one, as the additional outlay was such that it would have been saved in one season, and we would have been in a position to make the utmost use of our installed compressor capacity. Furthermore the improvement was right in line with any possible plan that may be worked out in the future, to increase both our ice-making and compressor capacity to a point where it will provide for the summer peak (estimated at 16 T. daily). The proposition fell through but we have hope of reviving it in the future.

How About the Human Element?

HUMAN relationship today is the major problem of industry, declared Charles R. Towson, of New York, secretary International Committee, Y. M. C. A., in an address delivered in New Orleans recently on the "Rising Standard in Industry" before the seventh annual meeting of the Southern Pine Association. Mr. Towson in an entertaining manner discussed the relationship between employers and employes, and the changes that have taken place during the last few decades. Among some other striking statements in his address were the following:

"The greatest thing in industry is not machinery, markets or material, but men.

"The great thing in man is not body or mind, but spirit.

"The great problems of industry are not wages, hours or conditions—things seen—but attitudes, motives and relations—things unseen.

"Working hours and conditions—things material, may and must be adjusted. Attitudes, motives and relationships—things spiritual, must be changed, converted.

"Man made in the image of God is a personality with a creative impulse. Anything that depersonalizes him, or stifles his creative impulse, injures the man, the industry and society as well."

Mr. Towson stated that because of America's remarkable industrial progress many striking changes have occurred in industrial values and relationships. "At first," he said, "such changes moved slowly like a succession of dissolving views, but today they make a veritable motion picture. At first this progress in organization, method and machinery moved with an aim toward one objective, production. In another decade, however, industry had taken on a larger objective. Now it must have not only production, but efficiency in production, meaning the largest output with the smallest waste of time, material or energy. Industry began to save material as never before, and also to guard the time element more carefully, as well as seeking to avoid a waste of energy.

"But while conserving material, time and energy the question has been coming 'how about the human element in industry?' Forward looking employers everywhere began to put a premium upon that production which secured the maximum amount with minimum waste of life, limb or human welfare and this marked the dawning of industry's bright day. But just as formerly it was difficult to induce conservative managers to discard old machines for new, so it has been with the introduction of human methods of dealing with the human factor; however, much progress has been made."

The speaker asserted that it took the experience of the war to reveal more clearly the real dimensions and the seriousness of the problem of this human factor. "With the experiences of the war," he said, "has come the clearer and more general realization that human relations is the great problem; that no adjustment of things such as wages, hours, conditions, can take the place of the thing for which God created man, namely, the expression of personality, for creative work with right human relations. Even now there is danger of failing to put first things first and of being stampeded into assuming that because there is a so-called new order of things belonging to a new day, we must put our hope in some of the philosophies and plans that range from the extreme left of radicalism to the extreme right of reactionary, forgetting that unless we have the essential elements for right human relations no legal or bargained adjustment will solve our problem.

"Leaders of labor, managers, directors and stock holders must realize the true basis of right relations—right character, which makes motives right. Many who formerly failed to do so are coming to understand the true place in productive industry which must be held by these unseeing but potent elements, integrity, intelligence, stability and good will.

"Integrity cannot be reduced to a formula, but it is a real financial factor; intelligence cannot be put under a microscope, but the lack of it is bound to show in the dividend column. The dollar and cents value of that intangible thing we call stability is, and always has been, great. Virtually all the industries have experienced losses and difficulties because of changing labor. What a penalty the industries pay for the floater!

"But the greatest of all these unforeseen forces is the good-will of the worker. Suppose every worker could be kept on the job. What will it amount to if the spirit of the worker is not right? The spirit of the worker is industry's greatest asset or liability."

Mr. Towson asserted that the physical welfare of the worker should be of great concern to every employer. "The employer is the party of the first part," he said, "and should initiate good-will-begetting methods. He may count upon the employes to respond in kind. The secret of success is not in paternally doing for men, but in fraternally co-operating with them.

"Autocracy in capital and autocracy in labor will die hard, but it must die," asserted Mr. Towson. "Co-operation is bound to grow in this country whether we take our industrial policy from the English labor program or that of the United States Chamber of Commerce; whether it be based upon the collective bargaining of the American Federation of Labor or the Rockefeller representation plan. Co-operation will grow because the masses of men, both employers and employes want it, and they want it because the spirit of good-will has taken root in America and will not be willed off by destructive radicalism."

Poems of Science and Engineering Wanted

I AM MAKING a collection of verses, whose subject-matter relates to the sciences, with the intention of publishing at some future date an anthology of this poetry. It has occurred to me that there may be quite a number of such poems in the possession of the engineers and scientists of this country which at the present time are quite unavailable. Will you kindly grant me space in your publication for this appeal to its readers to send to me copies of such verses, together with the names of their authors, to my address, Box 130, M. I. T., Cambridge, Mass.? Such verses sent to me at the above address will be greatly appreciated and duly acknowledged. CHARLES E. RUBY.

NOT WHAT is spent on a job, but what return it pays on the investment is the test of successful engineering.

Motor Stopping Device

SEVERAL YEARS ago I had charge of a plant which, being one of the old type, was scattered over a large area, making it necessary at times for the operating engineer to do some real foot work to be at the right place at the right time.

The plant was electrically driven, power being received from a hydroelectric power line adjacent to the property. One of the units was a duplex 12 by 12-in. belt-driven air compressor. This was a single-stage machine operating at 145 r.p.m. and delivering air at 100 lb. gage pressure. The pressure was regulated by an Erie unloader, making the load very irregular and the speed of the machine the same at all times.

Power was received through a 14-in. leather belt from a 75-hp. General Electric motor taking 3-phase, 25-cycle, 440-v. current. Due to lack of space, we had only 15 ft.

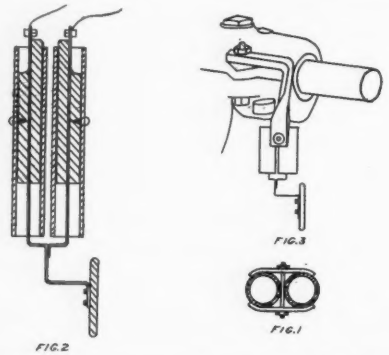


FIG. 1. END VIEW OF FIBER TUBES SHOWING METHOD OF CLAMPING TOGETHER

FIG. 2. SECTIONAL VIEW OF TUBES SHOWING PLUG FILLERS AND STEEL SPRING INSERTED

FIG. 3. SHOWING MOTOR BEARING AND BRACKET FOR ATTACHING APPARATUS IN LINE WITH DRIVE. PULLEY REMOVED.

from center to center of pulleys and here is where our troubles began. In the first place, we really needed an 18-in. belt to take care of the violent change of load, but limited space in the frame of the compressor made it impossible to use one wider than 14 in.

As a result, we were bothered with belt slippage and eventually burned up two belts in an effort to make it run regardless of conditions. We made some improvements by placing an idler on the belt near the motor pulley, thereby increasing the pulley area actually in contact with the belt; however, there was some oil leakage from the main bearings which found its way to the rim of the big pulley on the compressor shaft and at times when the unloader would open suddenly the compressor would slow down and stop and in the meantime the motor would caper along at normal speed playing havoc with the drive belt.

As the man operating this motor also tended several others more widely scattered about the plant, he could not be in this motor room all the time and as all engineers know, troubles of this kind have an uncanny way of happening when the operator is elsewhere.

After much worry and delay, I hit upon an idea which I thought would help out if not eliminate the trouble. The motor was equipped with a triple-pole, single-throw, automatic oil break switch, with overload, time limit and low voltage release. This overload release was of the usual type more or less familiar to all electrical engineers and motor tenders, consisting of a small coil wired across two phases on the motor side of the oil switch and so arranged that when energized it holds a trip in place, preventing the switch from losing contact. In case the load increases or the voltage falls below a predetermined point, the coil fails to hold the normal running position and releases the oil switch or circuit breaker.

After studying the proposition carefully, I noticed that when the belt began losing its grip on the motor pulley it invariably shifted from the center of the pulley toward the motor. I then rigged up an apparatus similar to that shown in the sketch herewith.

Briefly summed up, this is only a crude single-phase circuit breaker. We had on hand quite a number of 80-amp. enclosed fuses which were burned out and after selecting two with good bodies, I removed the metal ends from both of them and emptied out the contents. I then had two good fiber tubes 1 in. in diameter and about 6 in. long. I then clamped these together, side by side, as shown in Fig. 1, and proceeded to fix them up with additional parts to suit myself. In one of these tubes I placed a piece of fiber turned to fit the inside and sawed lengthwise with a hacksaw to take the strip of steel as shown. I rummaged the shop and found an old flat spring, presumably out of a phonograph motor, and cut off a piece 7 in. long. This I inserted in the saw cut in the fiber plug, fastening it firmly with screws as shown in Fig. 2.

One end of this strip of steel I bent at right angles and fitted the other end with a small bolt to act as a binding post for the wire connections. For the other tube I made a fiber plug similar to the first one, except that the steel was bent as shown in Fig. 2 and shaped so that at normal position the two steel strips made contact. On the lower end of this piece of steel I fastened a piece of fiber as shown and the top end was fitted with a small bolt for wire connection same as the other one.

When these were all made up I placed a roundhead wood screw through the wall of the tubes into the fiber

plugs to hold them firmly, being careful, of course, not to make contact with the steel strips inside. I was then ready to install it for a trial.

Taking a piece of ⅜ by 1½-in. bar iron, I made a bracket as shown in Fig. 3 and clamped it down with one of the bolts in the motor bearing on the pulley side in such a way that the fiber lug on the lower end of the steel spring was in line with the lower edge of the drive belt and close enough so that when the belt starts slipping and moves an inch toward the motor it will promptly make a bearing on the fiber end of the long spring.

I then wired this apparatus up in series with the coil operating the overload release and started the motor as usual. What I had was merely a switch in this coil line, so arranged that when the belt started slipping it promptly brought a pressure on the long spring, opening the circuit to the release coil which in turn released the oil break switch and stopped the motor instantly.

It worked like a charm and never failed to stop the motor during 4 yr. of service after which the old compressor was replaced with a new machine with sufficient pulley area to eliminate the belt slipping hazard.

E. H. McEuen.

Electric Control for Sump Pump

In a building where I was employed the power plant was located below the sewer line; consequently all drainage was collected in a sump-tank, set in the basement floor, and from there pumped to the sewer by a small electric pump having no automatic control.

It was the custom among the employes for whoever happened to notice the tank nearly full or overflowing on the floor (as it frequently did) to close the switch and start the pump. Later somebody else might remember to shut it down; perhaps an hour later, although it required less than 10 min. to empty the tank.

From material found in the scrap pile a device was constructed to stop and start the pump as needed. On a piece of slate two magnet coils from old arc-lamps were firmly clamped so as to attract an iron lever swinging on a pin. The top end of this lever was attached to a double-pole knife-switch by a fiber rod,

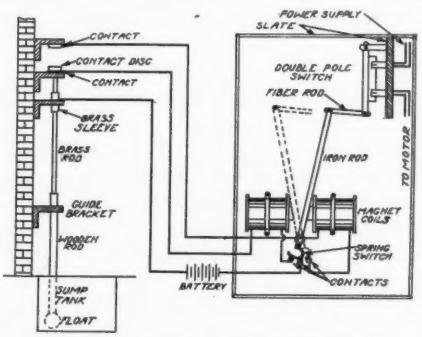


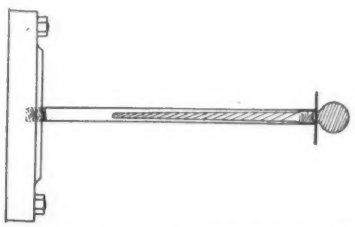
DIAGRAM OF SUMP PUMP CONTROL

the switch being secured at right angles to the slate back. A piece of spring brass was bent to shape and secured to the bottom end of the lever and insulated from it as shown. This acted as a switch for the control current, making contact with three copper blocks fastened to the slate. At the tank a copper float was attached to a wooden rod passing up through a guide bracket on the wall. A brass rod at the top of the wooden rod passed through a bracket carrying a brass sleeve, making a sliding contact, to which one battery wire was attached. Two other light wooden brackets supported copper contact plates on which the disk at the top of the rod made contact. In operation, when one circuit was closed, one magnet acting on the lever closed the motor switch and at the same time set the switch at the bottom of the lever for the other magnet to operate. This device worked very satisfactorily. The sketch shows a battery in circuit, but in our case we operated from a motor-generator set, used for elevator bells, sprinkler, and fire alarm systems, etc.

M. M. Brown.

Filing Circular Charts

We had in our plant a number of recording thermometers and pressure gages producing the standard circular chart, which records we desired to keep for at least six months for comparative and reference purposes.



CONVENIENT AND EASILY MADE FILE FOR CIRCULAR CHARTS

At first we filed them away in large manila envelopes, but this involved a great deal of work in filing and made it inconvenient to refer to them. We then filed them on wooden pegs which was a great improvement, but we found that when we had to take one of the charts off the peg it meant removing all the charts which had been filed subsequently, and sometimes it took a bit of time to replace them. We then hit on a design for a chart holder which, while it probably is not new, is interesting enough to warrant illustration for some other engineers may find it to be a time-saver, as we have.

We took a small blank flange, tapped it, and attached a piece of ¼-in. brass pipe about 8 in. long, the outer end of which was threaded on the inside. Then we made another piece about 6 in. long to fit into the inside of the pipe and provided with a screw to engage the thread, as well as with a knob handle, all as shown in the attached illustration. The screw was made with only a turn and a half, just sufficient to insure its holding. The charts could be placed on this file, which was bolted on the wall in the office in a few seconds, and it also has the advantage that if an old chart is to be referred to, the subsequent charts can be slipped off onto the loose handle and its long piece of brass so that by inserting this piece into the pipe the charts can be slipped back in a second.

M. A. Saller.

Small Pipe Gives Trouble

The quantity of water being delivered by a steam pump was much under what it should have been. Examination disclosed the reason. It was not the fault of the pump; it was the fault of the man or men who installed it. The suction pipe was over 80 ft. in length

with a 20-ft. lift. This was all right, but they had reduced the suction inlet from 3-in. to 2-in.. Besides using several 90-deg. short elbows on the pipe, increasing the suction to the proper size and using long bends restored the good reputation the pump deserved.

I believe the engineer who installs a ½-in. blowoff on the water column would be wiser in using a larger size. A column blowoff should be large enough to empty the glass and column when both connecting pipes and the blowoff valves are open. This means the blowoff should be as large in diameter as one of the connecting pipes (both of the latter being the same size, of course), be they ¾-in. or 1¼-in., the latter for preference, as there is considerably more chance of a small lower connection closing up with scale than there would be with one of larger diameter. Of course, a 1¼-in. blowoff could not run into the ashpit in many cases without raising the danger of injuring the bridge wall or of blowing ashes out into the boiler room should the ashpit doors be open when blowing down the columns, but if the pipe could be connected to a sewer or by partly circling the boiler such a column blowoff could be connected to the boiler blowoff. Wherever possible, this pipe should discharge where it can not do any harm.

JAMES E. NOBLE.

Water at $10 a Ton

THE COAL question is a subject that vitally interests all of us. Some engineers do not keep posted on the price because it is sometimes difficult to find out and we do not always feel like asking the plant owners for fear they might think we were trying to get a line on the profits, but the price question is not always the only vital thing. For instance, we might be paying $8 a ton for coal testing to 14,000 B.t.u. and prefer to use this because another coal dealer has coal that tests only 13,500 B.t.u.; but what about moisture?

It makes a big hole in the profits and B.t.u. if the first coal dealer has 10 to 15, yes, and 33 per cent of water in the coal. It is not uncommon these spring days to have delivered to us coal that has been stored outside and uncovered all winter, coming to us in frozen lumps except what is partly thawed out but well soaked with melted ice. You pay for a ton of coal and if it contains 20 per cent of moisture you have got 1600 lb. of coal and 400 lb. of water; the latter, of course, you can't use but yet pay the price just the same as though it were real coal.

I have seen numerous cases of this kind and there is practically no redress. I have changed, and the other dealer also has frozen coal. I had a load of coal recently that looked quite wet so I decided to find out how much water it contained. I took a 52-lb. sample and after drying on the boiler it weighed 39 lb., showing that it contained 13 lb. of water which, of course, is 25 per cent moisture.

I have done some complaining to the dealer. I got it down to 12 per cent moisture, but I have had coal that showed 33 per cent water when delivered. It is surprising how much moisture there is in coal that looks fairly dry. I had some that looked dry enough, although not thoroughly dry, but yet it contained 10 per cent of water to my surprise.

It is not uncommon for men who unload vessels to be standing knee deep in water in the vessel's bottom, due to the leaking vessel. Imagine the profits made by the dealers per year by allowing their steam coal to collect moisture as it does and by selling water at $10 per ton. The Bureau of Mines has long ago told us that wetting of coal is a thing of the past for economy. This muleting should be taken up by men whose business it is to enforce justice and compel coal dealers to sell dry coal or else make an allowance for the percentage of moisture.

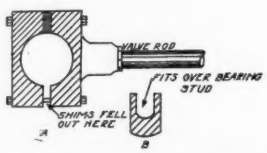
A. WALDRON.

Locating Noise in Eccentric

HAVE YOU ever had trouble with some apparatus under your charge, the cause of which you could not find, no matter how you tried, but which in the course of time you happened to locate quite accidentally?

The writer had this experience a short time ago when there was a clicking noise in the eccentric of a high-speed steam engine, the cause of which I could not locate. Some days the noise seemed to be in the steam valve, on others it seemed as if it was in the eccentric straps. The noise was much worse when the steam pressure was low and when there was a heavy load on the engine; also when the pressure was high with a light load on the engine. I examined the eccentric as well as the steam valve a number of times but found nothing wrong.

One morning, while starting up the engine, I happened to look at the rocker arm bearings of the eccentric rod and noticed that the eccentric rod bearing cap



SHOWING CAUSE OF NOISE IN ECCENTRIC

was loose. In further examining, I found that the sheet iron shims between the bearing and cap had dropped out as shown in the illustration at A. The type of shims used is shown at B. This allowed the bearing cap to move forward and back at each revolution of the engine, causing the clicking noise, the cause of which it took me some time to locate and then I discovered it by accident.

After replacing the shims and adjusting the bearing cap, there was no more noise.

I did examine the rocker arm bearings as to their tightness, but was under the impression that there was not sufficient lost motion to cause the noise, not noticing that the bottom shims had fallen out. In dropping out they had fallen in such position on the engine frame that they could not be easily noticed; if they had dropped on the floor I should have noticed them sooner or later.

H. A. JAHNKE.

Running Evaporation Tests

ALL POWER plants are in some measure credited with efficient operation or the reverse in proportion to the amount of water evaporated per pound of coal consumed. The evaporation test is essentially simple in theory at least and not many plants of any size fail to have some mode or other of measuring the feed water used; but

it would be interesting to many to know whether the figures obtained are really trustworthy. For instance, if each power plant operator really knew the amount of water lost in blowing down the boilers and would make deduction for it, he would find himself short of the figure he usually claims for evaporation.

Another instance developed recently when it was found that hot water from the feed water heater supplied water for six or eight baths daily after passing the feed water meter. The high quantities of water evaporated as shown by the reports from the station were questioned and an official test was made, bringing to light this and other inaccuracies in the daily reports.

It would seem that test runs should be made now and then if for no other purpose than to check up the regularly reported results. An instance could be cited where feed water temperature was reported at 210 deg. F. regularly and investigation developed the fact that the thermometer had been broken and out of service for months. Of course, such things should not happen; but they certainly do. The weight of coal used is probably never over-estimated or reported from many plants. Only the accounting departments know how much more coal was paid for than was reported used.

No surer way to get good results has been found than keeping accurate accounts of performance. The rest follows inevitably. GEORGE C. LOVE.

That Simple Well Kink

I WAS interested in the account given by H. W. Rose of the use of a vacuum pump for clearing a choked air pipe employed for levitating and quickening the water discharge of a flowing well, and I offer a word or two of suggestion.

Compressed air is often used quite satisfactorily for this purpose, but even here the conditions of application make a difference. One-tenth the number of the little holes in the pipes would have been sufficient but the greater number were not objectionable. The closing of the pipes at the bottom was a mistake and the cause of the trouble. If the pipe had been left without any closure all the rust and dirt would have dropped out and left the pipe clear and the air would have been glad enough to escape through the little holes without ever reaching the bottom of the pipe.

The relief accomplished by the vacuum pump, although real enough for the time being, could only be temporary and would before long be called for again. It did not remove all the rubbish that clogged the lower end of the pipe, but only enough of it to clear a few of the little air holes nearest the top.

FRANK RICHARDS.

Stress in Pipe Bends

THE WRITER read with interest the letter by H. D. Fisher in the March 15 number of Power Plant Engineering, particularly his statement that in thicker wall pipe the expansion allowance is less than in standard pipe. He says that the allowable expansion is inversely proportional to the thickness.

On page 802 of Marks' Mechanical Engineers' Handbook, I find this statement:

"Extra strong pipe bends have practically the same expansion value as the corresponding shape full weight pipe bends."

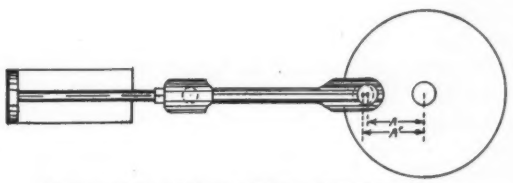
It appears that Mr. Fisher is using the Crane formula for determining pipe bend radii, allowable expansion, etc., and at the same time I believe that the above quotation taken from Marks' Handbook was originally copied from the report by the Crane Company which appeared in their Valve World in October, 1915. I haven't a copy of that issue of the Valve World, but that publication seems to be the source of our present knowledge, if I interpret Marks' Handbook correctly.

It may be that pipe thickness should be given consideration, but I myself cannot see why in view of the fact that stresses and strains are always directly proportional to the distance of the fibres from the neutral axis. That being the case, I cannot see why the thickness of the wall should enter at all.

W. F. SCHAPHORST.

Engine Knock

SOME TIME ago our engine developed a severe knock at both ends of the stroke. Keying up on the engine did not remedy the trouble, so the piston was taken out of the cylinder for the purpose of inspection. It was thought that a loose connection might exist at the point of attachment to the rod, but no fault of this kind was found—the rod was perfectly tight.



SKETCH SHOWING HOW WEAR ON CRANKPIN INCREASED LENGTH OF STROKE

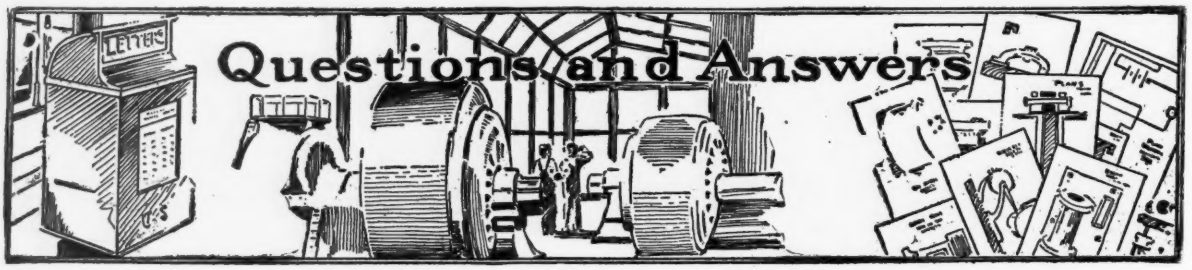
Finally we decided to check the clearance, which we had not thought of doing at first on account of the knock taking place a both ends of the stroke. To our surprise we found the piston striking both ends of the cylinder and discovered that it was caused by the crankpin wearing on only one side as shown in the sketch.

The crankpin wearing in this manner increased the distance between the center of the shaft and the center of the pin, this in turn increasing the stroke of the engine. The rod had been screwed into the crosshead at various times to equalize the clearance until finally the wear on the pin became so great that the piston began to strike both ends of the cylinder. The trouble was remedied by inserting gaskets between the cylinder and cylinder head, thus increasing the length of the cylinder, until a new pin could be obtained. A. G.

Worth Remembering or Jotting Down

TO CONVERT gallons of water per second into pounds of water per minute, multiply the former by 500; or, multiply the gallons of water per second by 1000 and divide by 2.

To convert pounds of water per minute into gallons per second, divide the pounds of water per minute by 1000 and multiply by 2. N. G. NEAR.



What Is the Effect of Counterbore?

In the plant which I operate there is a 16 by 36-in. Corliss engine running at 98 r.p.m., which pounds heavily on both ends of the stroke. Twelve years ago last August it was rebored, rebabbited and put in alinement, and until last November ran smoothly with no knock. At that time the valve seat was rebored and new valves put in. The machinist set the valves and the engine was run for one 8-hr. shift without signs of knocking. During the next off period the cylinder was rebored, the piston fitted with new ball and steam rings, and the main bearing rebabbited. On the next shift, after having run about 30 min., it started to hammer and pound. I increased both compression and lead without apparent improvement.

After that I adjusted the alinement and then had a look into the cylinder. I found that there was no counterbore. My belief is that therein lies my trouble. In my experience I have found that an engine runs more smoothly with a counterbore such that the steam ring overlaps about 1/32 in. at the end of the stroke. Am I right or wrong? I would like to have the opinions of readers of Power Plant Engineering on this question.

F. R. B.

Electrical Maintenance Examination Questions and Answers

In order to reduce to a minimum fire and personal hazards in connection with industrial electrical installation, many municipalities now license electricians in charge of such installations. Before granting a license to the electrician, however, he is required to pass a more or less thorough examination. The questions asked are both theoretical and practical in nature, as is evident from the following which indicate the type recently put up to applicants for an electrical maintenance license in the city of Milwaukee, Wis.

1. Give the safe current-carrying capacity in amperes of rubber-covered wires ranging in size from No. 16 to No. 6 B. & S. gage, inclusive.

2. Describe a balance coil.

3. How would you parallel two direct current generators?

4. Draw the diagram of connections of some standard make of compensator used in connection with a 3-phase a. c. induction motor, such compensator to be provided with overload relays and no-voltage release.

5. How would you reverse (a) a shunt-wound d. c. motor; (b) a 3-phase a. c. induction motor; (c) a repulsion induction motor?

6. State in detail the rules to follow in connecting a heating device having a capacity rating in excess of 660 w.

7. A 220-v. direct-current generator can deliver 100 amp. when operated at capacity. How many circuits may be connected to this machine?

8. What size conduit would you use for three No. 6 B. & S. gage rubber covered wires? For three No. 00 B. & S. gage rubber-covered wires?

9. Determine the size of mains and branch for a 20-hp. 220-v. direct current motor.

10. State how lighting units shall be wired in rooms where explosive vapors may exist.

11. Why is it necessary to use a starting box in connection with a d. c. motor?

12. Draw a diagram of connections of a shunt-wound d. c. motor equipped with a starting box.

13. How shall low voltage three-wire direct current systems be grounded?

14. What size wire should be used to ground (a) 3-wire, d. c. systems? (b) alternating-current systems? (c) three-phase systems?

15. How should three-wire, direct current generators be protected against overload?

16. Why, except in single-machine installations, are alternating-current generators not provided with some form of overload protection service?

17. State reason for carrying all wires of an alternating-current system in a single conduit.

18. A generator delivers current at 220 v. when the armature operates at a speed of 500 r. p. m. By what two means would it be possible to raise the voltage of the machine?

19. Upon what three factors does the resistance of a conductor depend?

20. What kind of insulation shall be used on the conductors carried between the contact plates of rheostats and the resistance elements? How should these conductors be mounted?

Answers

1. Size of wires	Current carrying capacity
No. 16 B. & S.	6 amp.
No. 14 B. & S.	15 amp.
No. 12 B. & S.	20 amp.
No. 10 B. & S.	25 amp.
No. 8 B. & S.	35 amp.
No. 6 B. & S.	50 amp.

2. Essentially a so-called balance coil is an inductance coil consisting of several turns of insulated wire wound upon a laminated core and with its terminal connected to diametrically opposite taps of the armature winding of a three-wire generator; the central point of the winding of the coil is connected to the neutral lead. Sometimes the balance coil is built integral with the armature while other times it is entirely separate from the generator being connected thereto through the medium of collector rings.

3. Assume one machine to be in operation and already supplying energy to the distribution system. Bring the incoming generator up to proper speed, after which by means of the shunt field rheostat cut sufficient resistance out of this circuit as will allow such excitation of the fields as to produce a terminal electromotive force corresponding to that of the bus bars; that is, of the operating generator. After this has been done, throw in the equalizer and then the main switches. Proper load division may be accomplished by adjustment of the shunt field rheostat of the two generators.

4. See Fig. 1.

5. The rotation of a shunt-wound direct current generator may be reversed by reversing either the armature leads or the shunt field leads. The rotation of a three-phase alternating current induction motor may be reversed by changing the connection of any two of the machine terminals. When the brushes of a repulsion induction motor are placed ahead of the center line of the magnetic fields, the machine will rotate in a clockwise direction, while if the brushes are shifted back of the center line of the magnetic field, counter-clockwise rotation will result.

6. Each heater of 6 amp. or more or 660 w. or more must be protected by a cut-out. Each heater of more than 6 amp. or 660 w. capacity and each group of heaters not exceeding 6 amp. or 660 w. capacity must be controlled by a switch plainly indicating whether "on" or "off," located within sight of the heater arranged to cut off all current from the heater. Where

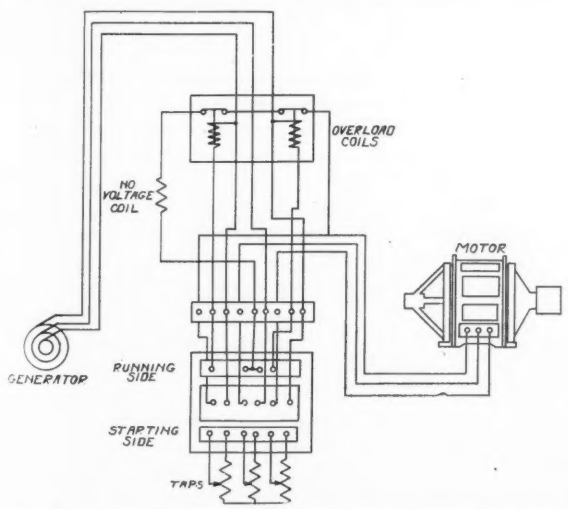


FIG. 1. DIAGRAM OF CONNECTIONS OF COMPENSATOR FOR 3-PHASE MOTOR

the capacity of the heater does not exceed 15 amp. or 1650 w., an approved plug connector may be employed in lieu of a switch.

7. At capacity rating, this machine can deliver 220 times 100, or 22,000 w. As a single circuit is supposed to carry no more than 660 w., this particular generator can serve 22,000 ÷ 660 or 33 circuits.

8. For three No. 6 B. S. gage rubber covered wires, use a 1¼-in. conduit and for three No. 00 rubber-covered wires use a 2-in. conduit.

9. A 20-hp. motor at rated load will require 20 times 746, or 14,920 w.; with an efficiency of 90 per cent, however, the total energy consumption will be equal to 100 (14,920 ÷ 90) or 16,577. The current will then be equal to 16,577 ÷ 220 or 75.3 amp., thus requiring a No. 3 B. & S. gage conductor for the mains. Branch leads must, however, be of a size sufficiently heavy to carry at least 25 per cent overload or in this case 94.1 amp., a current requiring the use of a No. 1 B. & S. gage wire.

10. Where explosive vapors are apt to exist, a vapor-proof globe shall be used to enclose both lamp and socket, the socket shall be of the keyless type and the conductors shall be rubber covered and soldered to the socket terminals.

11. Starting boxes are required in connection with direct-current motors to prevent the flow of excessive current through both the armature windings and the supply conductors.

12. See Fig. 2.

13. Low voltage systems shall be grounded only when under ordinary conditions of operation the current through the ground wire shall be negligible. When

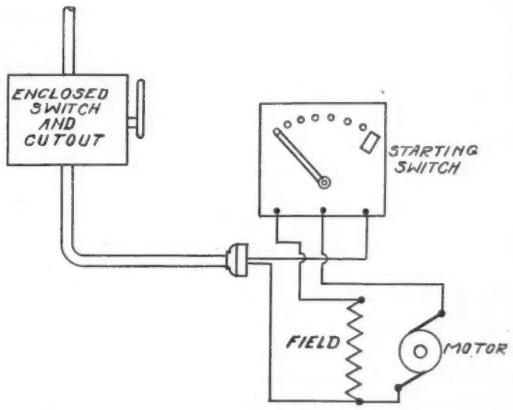


FIG. 2. DIAGRAM OF CONNECTIONS FOR SHUNT WOUND D. C. MOTOR STARTER

grounded, however, the following rules shall be complied with: The system shall be grounded at the central station and the ground connection shall be permanently made and shall include a complete metallic piping system. In underground systems the neutral shall be grounded at every distributing box through the box. In overhead systems the neutral shall be grounded at least every 500 ft.

14. In three-wire direct current systems the neutral shall be grounded at the central station with a conductor having a current carrying capacity equivalent to that of the neutral and elsewhere, with a conductor no less than No. 6 B. & S. gage. On alternating current systems, the ground wire shall be at least a No. 6 B. & S. gage and on three-phase systems the current-carrying capacity shall be equal to that of one of the mains.

15. On 3-wire direct current generator installations, there should be used either (a) a two-pole circuit breaker with one pile connected in each armature lead and each breaker equipped with its individual overload relay, or (b) a four-pole breaker with one pile connected in each armature and equalizer lead and so fitted with overload relays that upon the occurrence of an overload the four poles will open simultaneously.

16. Except in single-machine installations alternating current generators are not provided with overload protective devices. This is primarily due to the fact that, due to the high degree of reactance of the windings of such machines an excessive overload can do little or no damage and, further, with any individual feeder overloaded or short-circuited the overload protective device on such feeder shall serve to protect the generators.

17. To avoid excessive heating and choke coil effect due to self-inductance.

18. The machine voltage may be raised by increasing the speed or increasing the degree of field excitation or both.

19. The resistance of a conductor is dependent upon the material of which it is composed and is directly proportional to its length and inversely proportional to its cross-sectional area.

Asbestos-covered wire shall be used for this service. The various leads may be grouped, provided that a potential difference of no more than 75 v. shall exist between any two conductors of each group. The group of conductors may be carried by porcelain insulators ½ in. above the surface wired over or may be carried in an iron pipe with flexible insulating tubing protecting the conductor from injury. This tubing shall extend at least 1 in. beyond the ends of the pipe.

ELECTRICIAN.

Boiler Vibration

THE DIFFICULTY described in the article under the caption "Peculiar Case of Vibration Stopped Accidentally," which was published in the March 15 issue, appears to be a splendid example of harmonic vibration.

Every elastic body has a certain natural frequency of vibration at which it will readily vibrate, if it is actuated by a disturbing force which has a frequency, the same as the natural frequency of the body. The vibratory force which originates such harmonic vibrations may be exceedingly small and yet produce vibrations of considerable amplitude in the elastic body.

In the case referred to, the natural frequency of the suspended boiler shell happened to be 400 vibrations per minute. Hence it was caused to vibrate harmonically by the unbalanced forces which were originated by the 200-r.p.m. engine which cut off 400 times per min.

When the elastic properties of any body are changed, its natural frequency of vibration is changed accordingly. Thus, in this case it appears that the weighting of the boiler shell changed its natural frequency of vibration, so that it no longer would vibrate harmonically with the engine; therefore, the vibrating of the boiler shell ceased, after it was weighted with the magnesia and brick. In general, the weighting of any object changes its natural frequency of vibration.

TERRELL CROFT.

IT WOULD appear the loading of the top of the boilers with the 3-in. asbestos and a brick blanket, was sufficient to change the center of oscillation to such an extent as to remove it altogether, just as the sensitiveness of a scale beam is affected by the position of the knife edge, forming its point of support, with reference to the center of gravity of the scale beam, itself.

At the time the new engine was installed, the initial vibrations could have been avoided by changes in the piping connections between the boilers and the engine. These changes are as follows:

1. The 7-in. pipe header section leading from boiler No. 2 to the engine should have been at least 9 in.

2. The 6-in. horizontal pipes from the boiler stop-valves to the engine header should have been at least 10 ft. long.

3. The engine header should have been suspended from the ceiling, or roof, at two points near the boiler connections.

The report says: "The boilers made a bounce for each cutoff of the new engine," i. e., 400 bounces per minute, indicating 200 r.p.m., which is a large increase (128 r.p.m., or 56.2 per cent) in the pulsations of steam over those required by the old engine at its 72 r.p.m. The former engine was supplied through the 7-in. header section, whose area (0.785×49) is less than the (0.785×72) required for two 6-in. pipes. The 9-in. header suggested gives 0.785×81 sq. in., a surplus of 12½ per cent, which is none too great.

Evidently the governor of the new engine was sensitive and efficient, producing fairly regular pulsations of steam through the 7-in. header; thus causing vibrations of approximate regularity which are easy to sustain, and undesirable because dangerous to connections.

Variations in engine load were causing irregular volumes of steam to pass through the 7-in. header at each piston-stroke, while the latter were fairly regular, a condition which seems to have been overlooked by the investigators.

The change to 12-in. I-beam supports for the boilers was proper, to add rigidity, and, at that time, the boiler stop-valves should have been applied, "hand-wheel on top," to "stop" against the boilers, instead of against the engine as drawn, an installation which requires the boilers to be shut down to pack the valve-stems, in addition to bringing undesirable and destructive strains on the valve bodies when the valves are closed and the boilers under steam.

Where steam is given a comparatively uninterrupted flow, vibrations are not set up, whereas pulsations of flow in an engine or outlet-piping from a "pop" safety valve will produce vibrations. Liquids in motion are affected in the same way under like conditions.

The foregoing facts are, or should be, well known, and given careful consideration in planning piping connections to have them always large enough to insure free flow while delivering the quantities, or volumes, required for any given service.

High speed engines of any type require "good lungs," so to speak, because they are, in fact, veritable pumps on the boilers, necessitating large piping connections thereto.

The two 72 in. by 18 ft. boilers had a large contract to fill to supply the new engine when run at its capacity. At the speeds given, its piston displacement is over 70 per cent greater than that of the old engine, and no changes were made in the engine header, when the new engine was installed.

J. T. B.

BOILERS THEMSELVES do not produce vibration. It has to be acquired from another source, and that most naturally is from the unit that is generating the power

for the plant. As the unit receives its power from the boiler, the boiler will vibrate if it is not as securely anchored as the engine. If the pipe connections are wrong, some disaster is at some time sure to occur.

From the diagram of the boilers and engines, unless the engine is upon a perfectly solid foundation, it will vibrate these boilers, and of course the high-speed engine produces it more so than the slow speed. All of this trouble might be eliminated by placing in the main steam line instead of the ell that turns the steam pipe down to the engine, a long sweep U bend, which would act as an expansion and contraction joint, and at the same time as a vibration preventive.

H. W. Rose.

Indicator Sticks

With regard to the inquiry of E. P. C. and W. J. M., page 340 of the March 15 issue of Power Plant Engineering, I would like to say that the diagrams from the high-pressure cylinder of the angle-compound engine, Fig 1, seem to show that the indicator piston was sticking. It was not working freely, possibly for lack of lubrication, or because the pencil point was pressed too tightly against the paper while taking the diagrams. Both diagrams show a stiff, jerky action that cannot exactly be charged to faulty valve action, but rather to the indicator itself, or to the manner of using it.

However, the lead at the head end is a trifle late, as indicated by the sloping forward lead line on the diagram. Also, it seems that the exhaust valves close a little too early, even considering the 300 r.p.m. and piston speed. The diagrams are so "shaky" looking that a false estimate may be made of valve adjustment, and also of the steam distribution. Before anything is done in the way of changes, the indicator cylinder and piston should be examined, and if found correct, the piston should be oiled with cylinder oil, which thins out when the heat is applied. Then new diagrams should be taken, remembering not to press too heavily against the paper card with the pencil point of the instrument. Only the slightest touch is necessary to produce the required outline of the diagram.

Next, with regard to the diagrams from the Corliss type engine, Fig. 2, here again the tremulous expansion lines seem to show a sticking piston in the indicator, or a too tightly pressed pencil point. But there are unmistakable signs that both exhaust valves open too late, as shown by the rounding toe of each diagram. If the valves had opened to release the steam at the proper time, the exhaust lines would have dropped to the back pressure line much quicker than actually shown. The engine is actually consuming more power to drive out the exhaust steam from the cylinder than is warranted. Otherwise the valve vents and steam distribution appear normal.

I would suggest that a little more angular advance be given the eccentric, in order that the exhaust valves can open earlier. If in doing this a corresponding earlier closing of the exhaust valves occurs, then the difference can be adjusted by changing the lengths of the right-and-left rods which connect the valve arms to the wrist-plate.

When the valves are properly set, and with the same load on the engine as when the diagrams were taken and other conditions the same, an earlier cutoff will take place, which means less steam consumed to do the same amount of useful work. The saving may not be large as measured by one day's work but in the course of time will amount to something worth while.

I trust that we shall hear again from E. P. C. and W. J. M. concerning these matters, as to what they do, and with what results. Charles J. Mason.

Power Factor Correction

With reference to V. H. Todd's answer to G. R. M. relating to "Power Factor Correction by Synchronous Motors," the writer is giving some explanations in connection with the accompanying vector diagram, that will possibly aid G. R. M. in understanding the matter.

There is always a certain amount of mechanical load that a synchronous motor will carry when giving maximum power factor correction, provided, however, that the system power factor is below unity with the motor in operation. The lower the power factor of the system the more mechanical load will the synchronous motor

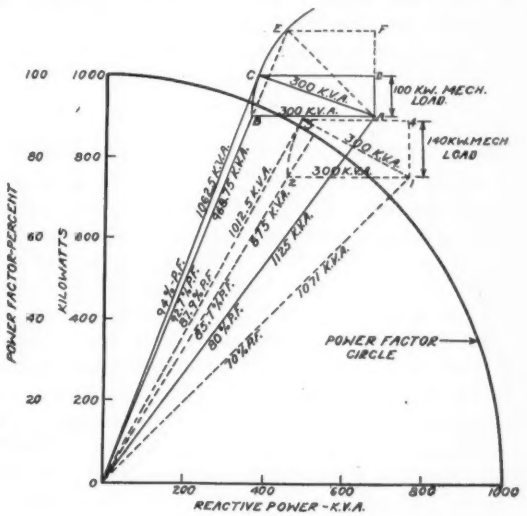


DIAGRAM EXPLAINING POWER FACTOR CORRECTION

handle in proportion to its size, and the higher will be the leading power factor of the synchronous motor.

By referring to the solid line diagram, it will be noted that line OA represents 1125 kv.a. at 80 per cent power factor, or 900 kw. AB represents a 300-kv.a. synchronous motor operating at zero leading power factor, and the corrected power factor is 92.7 per cent. By striking an arc with center at A and radius AB and drawing OC tangent to this arc, C being the point of tangency, OC will represent the system kv.a. and this line will intersect the power factor circle at the point of maximum power factor correction obtainable with a 300-kv.a. synchronous motor under the conditions as outlined in this problem, the final power factor being 94 per cent, the increase is 94 — 92.7 = 1.3 per cent.

Now refer to the dotted line vectors, lower diagram, and in this case the original load is 01, equals 750 kw. at 70 per cent power factor. Line 1-2 represents a 300-kv.a. synchronous motor operating at zero leading power factor, the kv.a. in this case being 875 and the power factor corrected to 85.7 per cent. Now, strike an

arc with center at 1 and radius 1-2 and line 03 drawn tangent to this arc will represent 1012.5 kv.a. and will intersect the power factor circle at the maximum point of correction, and is 87.9 per cent, and it is to be particularly noted that the motor is now handling 140 kw. mechanical load, and the motor power factor is 140/300 = 46.6 per cent leading.

One thing that is often lost sight of is the fact that there is always a certain amount of mechanical load that a motor will handle, and still give as much power factor correction as when operating at zero leading, and it is often the case that a mechanical load is of more importance than maximum power factor, and by referring to the dotted portion of the upper diagram it will be seen that AB produced to intersect the arc at E will show the conditions of equal power factor correction with AF representing the mechanical load on the motor. The motor power factor is 212/300 = 70 per cent, AF being 212 kw. The kilowatt load of the system will now be 1112 instead of 900, the load we had to start with.

In constructing a diagram of this kind, care must be taken to lay it out to scale, using any scale that is convenient, and this method may be readily applied to any practical problem for determining power factor correction by the use of the synchronous motor.

FRED C. DEWEESE.

Cause of Failure of Feed Water Pumps

IN REPLY to the question from A. H. F. in issue of March 15, on page 340, concerning boiler feed pumps, I should say that assuming that his feed pumps were working in good condition up to about two weeks before the trouble and that no changes were made in the system, there must be something mysteriously wrong. There are many reasons why the glands and cylinders would fail. One reason would be that the pumps were not receiving a sufficient supply of water which would cause them to race at certain periods. Possibly the suction pipes are corroded or perhaps a broken valve disc became loose and dropped into the suction pipe, preventing or reducing the flow of water to the pumps.

If the pumps were receiving water at various temperatures such as at 212 deg. one minute and 38 deg. the next, this action would have a dangerous effect on the metal not only of the pumps, but also of the pipes leading to and from the pumps, especially if they are not covered or insulated. Because of any of these reasons, the pumps could not be kept at uniform speed regardless of how they are governed.

If the receiving tank or open feed water heater is not placed above the suction line of the pumps and the feed water is at the boiling point, vapor is carried with the hot water into the pumps which will, by destroying the vacuum, cause the pumps to bang and pound, resulting in loose joints and cracked parts. The bottom or lower part of such receivers should be placed at least 6 in. above the water line of the pumps and a closed receiving tank should have a vapor line to the atmosphere.

PATRICK MOLLOY.

FROM A. H. F.'s explanation of his pump troubles as to breaking of studs, and glands, also cracking of cylinders, it would seem that the cause is either too hard a packing or incorrect adjustment.

It might also be caused by lost motion of the guide rods, but most likely it is improper packing.

H. W. ROSE.

IN REGARD to his pump failure, A. H. F. does not say whether or not there is a relief valve provided on the boiler feed line. From my own experience I should say that there is probably an obstruction in the feed line, either the check or feed valve may be stuck shut which would build up an excessive pressure in the water cylinders.

D. G. SIMMONS.

IF A. H. F. has his pumps packed with metallic packing and has it drawn up too tight with the stud nuts on the packing gland, he will surely have trouble.

At one time we bought some metallic packing for our fire pump. It was put in in due time and worked all right for about a month, when trouble began. The pump started to leak at the packing gland and packing was then drawn up tight until the water stopped leaking. It worked all right for a few hours when the pump started to break studs off as fast as a machinist could cut them in a lathe. The night engineer told us to take out that packing and put in new. I have seen valve stems, on both water and steam, packed by inexperienced men who left the old packing in gland and merely put a ring or two of new packing in and tightened down on gland nuts. After this treatment, it would not be a week before the same valve would leak again.

If these men would pack valves or pumps correctly, they would save themselves time and trouble and would also save the company money spent on packing.

C. A. S.

NO DOUBT this failure was caused by worn plungers, a shoulder being formed on the plunger at the end of each stroke where it was subjected to the friction of the packing. This could have been, and probably was, inside the cylinder, where it would not have been noticed without removing the plunger. As long as the pump runs with a certain length of stroke, continually, probably no trouble would result; but if the pump should lose its priming, or the stroke should be lengthened from any cause, the shoulders would strike the packing, and acting like a wedge, split the ends of the cylinder or break the studs.

The only remedy is to remove the plungers and turn them down in a lathe to the same diameter throughout their length. Upon repacking, if it is hard to find a packing of the right size, use a flexible packing, which will expand slightly under pressure of the gland.

I. F. RICHMOND.

Lubricator Refuses to Function

I WOULD like to suggest to M. C. K. that probably the reason why his lubricator would not work on the large pump is that his condenser tube was too short or else it was plugged up.

D. G. SIMMONS.

THE METHOD of piping this lubricator not having been given, I assume that the steam connection to the lubricator was made on the pressure side of the throttle and the feed connection made on the pump side of the throttle. In this method of piping there is more pressure on the steam side than on the pump side, conse-

quently the oil would feed too fast with a normal opening of the feed valve, so the valve is throttled down; this causes a wiredrawing action on the oil which soon gums up the opening and the oil doesn't feed. One would naturally think that with more pressure on the oil it would feed better, but actual circumstances have proved to me that it doesn't.

The proper way to connect the lubricator is to connect both steam and feed on the pressure side of the throttle, with the steam connection about 2 ft. above the condensing chamber of the lubricator. The water in the pipe from the steam connection down to the lubricator furnishes sufficient difference in the pressure to cause the oil to flow with a normal opening of the feed valve. I. F. RICHMOND.

Cleaning Scale from Ammonia Condenser

E. N. G. IN the issue of March 15, wants to know how to get rid of scale from the water pipe of his double-pipe ammonia condenser. He asks about the use of kerosene.

The practical method of dislodging scale from condenser pipes, as well as boiler tubes, is the same as that used to remove refuse, dirt or any other foreign matter—by actual physical cleaning. There is no uncertainty about the amount of scale removed by this means, as it can be seen, weighed and measured.

A safe way to eliminate scale is by vibration. Vibration means tapping the flue walls very rapidly so that scale is broken up and separated from the metal bodily. Cleaning tools which apply this principle are made for condensers as well as boilers, evaporators, economizers, etc. With their assistance, it is possible to clean the flues as clean as new, and the results of such a cleaning are quickly apparent. W. H. DAY.

Synchronizing Generator Equipment

IN REGARD to question regarding the synchronizing of generator equipment, on page 343 of the March 15 issue of Power Plant Engineering, I should say that the better and cheaper method would be to belt the engine to the turbine line shaft. A friction clutch located between the pulley driven by the engine and that driven by the turbine would be convenient and it will be found that if there is a governor on both the engine and water wheel, one or the other had better be disconnected as a steadier current will result. ALBION C. BARKER.

Readjustment of Valve Action to Improve Indicator Card

AFTER REVIEWING the questions by E. P. C. and W. J. M., I offer these suggestions:

In reference to the first indicator card, the head end diagram displays the fact that the live steam valve is opening too late, also that compression should be reduced. The crank end diagram shows an irregular expansion curve which I would presume was caused by lost motion in the valve gear, which, if eliminated, would correct this trouble.

Indicator card No. 2 appears to have entirely too much lead of both live steam valves, compression is a bit too low with exhaust valves opening too late. An 18 by 42-in. Corliss engine should have a steam lap of approximately 3/8 in., steam lead, 1/32 in., and exhaust lap, 1/64 in. With the piston on center, the eccentric is moved forward until the steam valve has the required lead and is then locked. It is then an easy matter to make finer adjustments of the valve action from the indications of the indicator diagrams. H. W. ROSE.

Changing Volumetric Flue Gas Analysis to Weight Basis

HOW CAN a flue gas analysis by volume be converted to give an analysis by weight? I have the following analysis by volume and would like to convert it to a weight basis.

Carbon dioxide	15.0 per cent
Oxygen	5.7 " "
Nitrogen	79.3 " "
	100.0 " "

H. O. A.

A. A flue gas analysis by volume may be expressed on a weight basis by the use of Avogadros' law, that the weight of any gas in pounds per cubic feet at 32 deg. F. and 14.7 lb. pressure is equal to $0.002{,}78 \times M$, where M is the molecular weight of the gas under consideration. As the volumetric analysis was probably not made at 32 deg. F., there will be some error introduced in the actual weights of the different gases; but the percentage by weight of the constituent gases will not be greatly affected.

The molecular weights of the gases mentioned are carbon dioxide, 44; oxygen, 32; and nitrogen, 28.

Weight per cu. ft. of each gas is then

Carbon dioxide	$0.002{,}78 \times 44 = 0.1220$ lb.
Oxygen	$0.002{,}78 \times 32 = 0.0890$ "
Nitrogen	$0.002{,}78 \times 28 = 0.0778$ "

The weight of each gas in a cubic foot of the mixture is then

Carbon dioxide	$0.1220 \times 0.150 = 0.018{,}35$ lb.
Oxygen	$0.0890 \times 0.057 = 0.005{,}07$ "
Nitrogen	$0.0778 \times 0.793 = 0.061{,}70$ "
Wt. one cu. ft. flue gas	$= 0.085{,}12$ lb.

The percentage by weight is then each individual item divided by the total and multiplied by 100.

Carbon dioxide	$0.018{,}35 \div 0.085{,}12 \times 100 = 21.55$ per cent
Oxygen	$0.005{,}07 \div 0.085{,}12 \times 100 = 5.95$ " "
Nitrogen	$0.061{,}70 \div 0.085{,}12 \times 100 = 72.50$ " "
	100.00 per cent

THE WORLD'S production of graphite in 1921 reached a lower figure than at any time since 1902, as shown by the statistics at present available, according to Arthur H. Redfield, of the United States Geological Survey, Department of the Interior. The world-wide depression in the graphite industry which characterized the year 1920 was continued in 1921. The stagnation of graphite mining in the United States is both a part and a result of world-wide conditions, the natural consequence of the over-production in 1917 that was stimulated by the abnormal demand for graphite crucibles during the World War. The world's production in 1921 was 85,000 metric tons, against 100,000 in 1920, 126,342 in 1919 and 136,498 in 1913. One metric ton is equivalent to 2200 lb.

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Developments in Use of Hogged Fuel

In the power plant field we have become so accustomed to the use of coal that comparatively little attention has been given to the economical use of some of the lower grades of fuel which are available in many parts of the country. Sawdust, shavings and mill refuse, commonly known as hogged fuel, is abundant in most localities where wood working industries prevail, yet comparatively little has been done towards developing furnaces and grates for its economical use. In most cases coal furnaces are used, the hogged fuel being thrown in on top of the coal bed and burned with little thought as to its value in making steam.

Where hogged fuel is used almost exclusively, however, it must be considered as having burning qualities entirely different from those of coal, and even the different varieties of wood show qualities which demand special consideration when designing furnaces. Probably more advancement has been made along this line in the northwest section of the country than in any other locality, and the present practice is well summarized on other pages of this issue by Mr. Morrison.

As an example of variation from customary practice with coal, we find hogged fuel purchased by volume instead of by weight; custom has established no standards of moisture content, chemical constituents or heat value; these, however, are likely to come with further development in the use of this kind of fuel.

In the design of furnaces, engineers have been guided largely by the experiences of those responsible for present practice in coal burning, yet we find extra provisions made for taking care of moisture, burning the high percentage of volatile constituents, and admitting air over the fuel bed. Methods of feeding the fuel to the furnace and caring for the ashes have come in for considerable study, but apparently there is still room for improvement judging from Mr. Morrison's statements and the things brought out in the discussion of his paper.

The success which has been attained in the use of hogged fuel leads the way to further investigations with other fuels of low heat value and high moisture content such as bagasse, tan bark, peat and lignite, all of which are available fuels in certain sections of the country. Each fuel, of course, presents a problem all its own. Anthracite, for example, is difficult to ignite, so heat reflecting arches and back drafts have been resorted to with success. Bituminous coals have characteristics, such as coking qualities, volatile constituents and fusing temperatures of their ashes which vary widely, and all of which have been met by properly designed furnaces and stokers. Brown lignite, with its high moisture and volatile combustible content and peculiar ash characteristics, has not been used with entire success in power plant furnaces and is still the subject of investigation by the government and several state authorities. Peat, in America, is almost unknown as an industrial fuel, although some experiments have been made with this kind of fuel in pulverized form. It may be proven, however, that the most economical way of using peat will be along the lines of experiments being conducted in England and described by Mr. Tupholme in this issue; that is, by carbonizing it, using the carbon as fuel for

the generation of steam and the volatile byproducts for other purposes.

There have been attempts made by some stoker manufacturers to standardize their equipment so that, given an analysis of the coal to be used and the conditions of furnace operation, they can specify the type of stoker and furnace dimensions which will give best results. This standardization has not reached so far as to include other fuels than coal, but it is hoped that the investigations being carried on in the Northwest will aid in this direction.

No problem in all industries is so important today as that of fuel; conservation is a real necessity when we consider the rapidly depleting resources of coal, oil and natural gas. Every substitute that can be pressed into service to delay the time when these fuels will be exhausted should be experimented with to the end that it may be used with the least amount of waste. Replaceable fuels such as are derived from wood demand especial consideration due to the fact that the world will ultimately be compelled to depend upon them and the sooner we learn their economical use the longer will our natural fuels last.

Diagram for Valve Setting

In the setting of engine valves, it is quite general practice to make what might be called a trial adjustment, guided by past experience and judgment. The amount of lead at each end of the cylinder is carefully evened up or perhaps, in the case of a vertical engine, one end is intentionally given more lead than the other. Possible variation in the position of cutoff is determined, for valve gears giving variable cutoff with changes in load, by blocking the governor in extreme positions. Release and compression are also determined by measurement and when all events are as nearly correct as the knowledge and skill of the engineer can make them, the engine is closed up and given a tryout running light and loaded.

The next step is to take indicator diagrams and see whether or not the results obtained are satisfactory. If they are not, a cut and try method of correcting them is usually resorted to. This, of course, takes time, and in most cases requires shutting down the engine several times before the desired results are obtained. Where time is not available for making such adjustments the engine usually runs along in an uneconomical way.

This experimenting to get the indicator diagram ideal for the type of engine from which it is taken is expensive, not only in time taken by those in charge of the engine, but in shut-downs necessary, and in the uneconomical use of steam during the period covered in getting the engine in proper working order. Engineers will welcome, therefore, the description of the use of the elliptical diagram given by Mr. Gates in this issue for making the final adjustments. Only one shut-down of minimum duration is required and guess work is entirely eliminated. This is certainly a step forward in the science of valve setting, and one which is well worth giving a thorough tryout on the various types of valve gears.

THE SUCCESSFUL short putt counts as much as the spectacular drive.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

The Comeback*

BY DR. FRANK CRANE

I FIND that the way I am treated in the day's work depends upon the state of mind I bring into it.

If I enter a circle of men whom I take to be superior to me, and if I impute to them the feeling that I am inferior I will not fail to be inferior.

If I am self-confident, I awaken confidence.

If I am cheerful, cheerfulness is handed to me by others.

If I am grouchy and snappy, they will bite me.

People go at me about the way I go at them.

There is a law in physics to the effect that action is equal to reaction. The ball rebounds from the wall with precisely the force with which it was thrown against the wall.

And if I approach a man with politeness, I usually receive politeness.

I get from this world a smile for a smile, a kick for a kick, love for love, and hate for hate.

Of course there are exceptions to this rule. But if there were no rules there would be no exceptions.

And the difference between the man who knows how to play a game and wins regularly—any game, including business, and the game of life—and the man who steadily loses is that the wise man sticks to the rules and the law of averages, and the fool "has a hunch" and stakes his all on the exceptions.

A good definition of a fool is one who thinks that this time doesn't count. This is a world of law. Chance is only to be found in the dictionary.

If I am petulant, unrestful, irritable, unsatisfied, wretched and bored—I know the crop, and might have expected the harvest when I sowed that seed of self-indulgence, lack of will, moral cowardice and general selfishness.

The loving are beloved. The generous are helped. The considerate are considered.

And the end of the hog is the slaughter house.

There are no victims of fate. The hero always rises above tragedy. The noble soul is never more serene than when all creation thinks it has downed him.

THE NEW ORLEANS Association of Commerce has requested the assistance of the Bureau of Mines in an educational campaign looking toward the abatement of the smoke nuisance in that city without necessitating the passage of legislation to accomplish the desired end. The Chamber of Commerce of Akron, Ohio, has also been in correspondence with the bureau regarding an anti-smoke campaign in that city.

*Copyright, 1922, by Dr. Frank Crane.

Two High Ampere Power Transformers

AN EXAMPLE of the forward trend in the development of power transformers is instanced by two machines recently built by the General Electric Co., which are of more than usual interest from the standpoint of the high amperage delivered. One was built for experimental welding at the Schenectady Works of the company, and the other for commercial application.

The first is rated 2300/4600: 19.17/38.34 v., single-phase, 60 cycles, and will supply 50,000 amp. continuously at 20 v. The maximum amperage obtained from it was 72,000 amp. when it was being used to weld together three steel plates each 1 in. thick. The total weight of the transformer is 4500 lb. without oil, the secondary copper alone weighing 1200 lb. The dimensions are 3.5 ft. square, by 6 ft. high to the top of the secondary terminal structure.

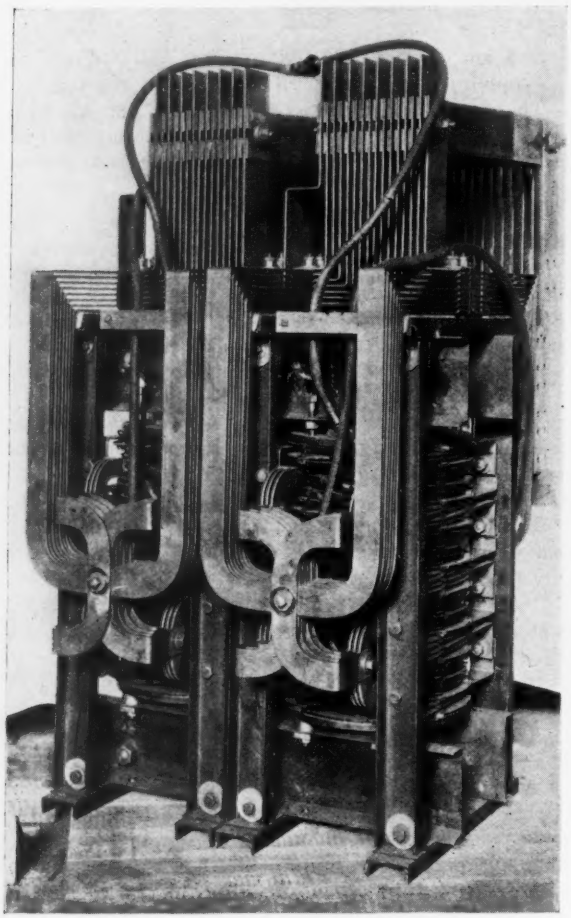

FIG. 1. SPECIAL TRANSFORMER FOR ELECTRIC WELDING. MAXIMUM CURRENT AT 19.17 V. IS 104,000 AMP. FOR 2 MIN.

In designing this transformer for 60-cycle operation, extraordinary precautions were taken to reduce the inherent reactance to a minimum. It was accomplished by carefully interleaving the secondary conductors in a symmetrical structure, a method only arrived at after long and careful study.

The second transformer is rated 2000 kw. single-phase, taking power from a 25-cycle, 11,000-v. circuit and stepping down to 110 to 50 v. on the secondary. On the lowest secondary voltage, it delivers 40,000 amp. with a full load efficiency of 98 per cent. The transformer weighs 51,000 lb., including oil, and is 10 ft. long by 7 ft. wide by 14 ft. high to the top of the leads. It has core type windings set on a vertical plan to facilitate the bringing out of the secondary leads, of which there are 16. Among the features of its construction is the bracing which holds the low voltage leads in position when they are subject to the forces generated by the high current. These leads have a total cross section of 16 sq. in.

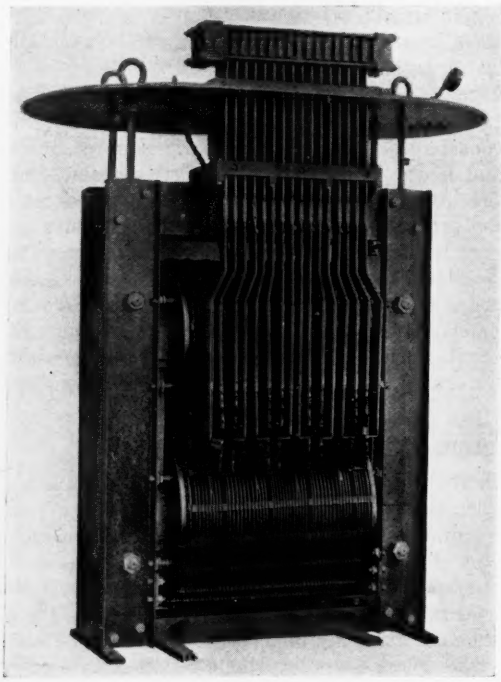

FIG. 2. TWO THOUSAND-KILOWATT, SINGLE-PHASE, HIGH AMPERE TRANSFORMER

New Central Station for Amory, Mississippi

AMORY, MISS., recently authorized a bond issue of $90,000 to finance a complete light, water and power plant.

The new power machinery will consist of one three-cylinder 175-b.hp. engine and one four-cylinder 225-b.hp. engine, both of the vertical, four-cycle Fulton Diesel type. The smaller engine will be direct connected to a 146-kv.a., 117-kw., .8 p. f., 2300-v. 60-cycle, 3-phase, alternating current generator with belted exciter, and the larger engine will be direct connected to a 187½ kv.a. generator of the same type, also with belted exciter.

Motor driven centrifugal water pumps will probably be installed, but this question has not been decided. A well lighted brick and concrete building of ample

size will be erected for the new machinery and space will be provided for a future third Diesel engine. When the new plant is ready to operate, the obsolete boilers, steam engines and other present equipment will be discarded.

Although Amory is nearer to coal than to oil, it was shown by the city's consulting engineer, F. G. Proutt, that with Diesel engines the net income on the light, water and power system would be more per dollar invested than with any other type of equipment. The low fuel consumption and other money-saving advantages of the Diesel engines will insure reasonable light, water and power rates for many years to come.

Burlington Building Power Plant Escapes Injury

ON MARCH 15 fire swept away an entire block in Chicago. Every building upon it was destroyed but one, the Burlington skyscraper, and that was gutted from the ground up.

Thirty-two feet below street level in the Burlington Building is a power plant, modern in every respect. This plant not only escaped uninjured but for hours while fire raged above and around it, was operated without pause. Chief Engineer Batzer and his men stuck to their posts.

A flood of water poured into the plant but all the equipment had been covered with tarpaulins and the water ran off the floor by drains into two sumps 8 ft. below the engine and boiler room floors. It came so fast, however, that it gained on the pumps. A foot or two more and the generators and boilers would be out of commission and the plant ruined.

Seventy feet below the building is an abandoned city water tunnel, with which the building had a connection. With two lines of hose the water was siphoned from the 8-ft. sumps into the tunnel 70 ft. below ground. It was then possible to put additional pumping equipment at work and to prevent the overflow of the big tunnel, elevate the water 72 ft. and discharge into the city sewer. The plant was thus saved from the damage due to a flood by the resourcefulness and bravery of its crew.

News Notes

THE CHICAGO branch office of the Belmont Packing & Rubber Co. has been moved from 38 N. Franklin St. to new and larger quarters at 170-172 N. Franklin St.

ARTHUR WHITCRAFT has joined the Hadfield-Penfield Steel Co., of Bucyrus, Ohio, in the capacity of manager of sales of the manganese steel department.

THE APPLICATION of evaporators to the purification of boiler feed water by distillation is covered in a general and non-technical way in a new bulletin, No. 360, published by The Griscom-Russell Co.

IT HAS BEEN announced that the McNary sub-committee of the judiciary committee of the Senate will report adversely on metric system legislation in the near future. This means that the metric bill will not be reported to the Senate.

A. P. BLACKSTEAD, formerly chief engineer of the Camden Iron Works (R. D. Wood & Co.), and prior to that hydraulic engineer with the Henry R. Worthington Co., has joined the engineering staff of the Dayton-Dowd Co., Quincy, Ill. Mr. Blackstead has had a broad experience on centrifugal pumps covering a period of over 20 yr., both in this country and abroad, and has recently returned from Europe where he spent 6 mo. studying conditions and investigating recent developments in hydraulic engineering.

THE MCCLAVE-BROOKS CO. has appointed the Mahler Machinery & Supply Co., Syndicate Trust Building, St. Louis, Mo., as sales representative for this district.

COMBUSTION ENGINEERING CORPORATION announces the opening of a new branch office in Guardian Building, Cleveland, Ohio. This office will be in charge of Frank Henderson.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO. has been awarded the contract for electrical equipment for a new power house to be constructed by the Southern California Edison Co. and to be known as Big Creek No. 3, which will have an ultimate capacity of 150,000 kw.

THE WILLIAM B. PIERCE CO., of Buffalo, N. Y., has within the last 60 days filled orders for boiler tube cleaners from Sumatra, Australia, Czecho-Slovakia, Sicily, Belgium and Brazil, which is an encouraging sign of the healthy condition of American business when it is considered that foreign exchange rates are a handicap to export trade.

FREEPORT SULPHUR CO., New York and Freeport, Texas, awarded contract on March 24 to Dwight P. Robinson & Co. for the design and construction of a complete sulphur mining plant at Hoskins Mound, Texas. The company now operates a large sulphur mining plant at Freeport, Texas, which contains one of the largest installations of oil-burning boilers in the world.

SANDVIK STEEL, INC., with offices in the Woolworth Building, New York, announces the consolidation of its general steel and steel belt conveyor departments with the following executive officers: W. D. Thomas, president and general manager; Anders Johnson, vice-president; Garrick M. Spencer, secretary; and Harry Carlson, sales manager.

PAUL L. BATTEY announces the opening of an engineering office at 123 W. Madison St., Chicago. His experience covering a period of over 20 yr. as chief engineer in charge of all kinds of industrial operations has fitted him admirably to serve as consulting engineer on the design, supervision and construction of complete industrial plants.

G. H. PFEIF has been appointed director of industrial relations at the Schenectady plant of the General Electric Co., succeeding E. B. Merriam, who recently became executive engineer of the switchboard department. As director of industrial relations he will have supervision over the employment, education and training, compensation, hospital and safety work of the Schenectady plant.

AT THE annual meeting of the stockholders of the Harrisburg Foundry and Machine Works, the following directors were elected for the ensuing year: Alfred Sohland, Christian W. Lynch, William Jennings, B. E. Taylor, Benjamin T. Allen, A. T. Jarrett and E. M. Lee. The directors accepted the resignation of Christian

W. Lynch as president and elected the following officers: President, Alfred Sohland; vice-president, A. J. Jarrett; treasurer, B. E. Taylor; secretary, E. M. Lee.

THE C. W. HUNT CO., INC., of West New Brighton, S. I., has re-established its New York City office at 143 Liberty St., and has taken over the sales and engineering work which has heretofore been carried on by its subsidiary company, the C. W. Hunt Engineering Corporation. The business of the two companies is to be consolidated.

C. E. SKINNER, manager of the research department of the Westinghouse Electric & Manufacturing Co., has been appointed assistant director of engineering in that company. His duties as assistant director will cover research, standards and other work along these lines. S. M. Kintner has been appointed manager of the research department, succeeding Mr. Skinner.

THE CHAIN BELT CO., Milwaukee, Wis., has announced the appointment of G. F. Sherratt as manager of the Pittsburgh office in the Union Arcade Building. Mr. Sherratt will be in charge of all the company's chain and engineering business in the Pittsburgh territory. The Ward Equipment Co. and the United Equipment Co., of Pittsburgh will continue to handle the complete lines of Chain Belt Co. products which they have handled in the past.

Books and Catalogs

A LIFE OF GEORGE WESTINGHOUSE by Henry G. Prout for the American Society of Mechanical Engineers; New York, 1921.

One of the fine tributes that have been made to George Westinghouse is the manner in which this biography has been written. Owing to the fact that Mr. Westinghouse was interested in so many things at the same time, it was found almost impossible to follow a comprehensible chronological order. Instead, his life has been reviewed in connection with his undertakings, following through one interest at a time. For instance, at the time of the Burlington trials of the air brake in 1887 there occurred simultaneously a great amount of work on the alternating current, the transformer, the induction motor and the polyphase meter.

When it is remembered that the perfection of the air brake and the introduction of the alternating current have been two of the greatest factors in our industrial development, it is amazing to think of the energy of Westinghouse to carry on such projects simultaneously.

The main chapter subjects are the Air Brake, the Friction Draft Gear, Electrical Activities, the Induction Motor and Meter, the Rotary Converter, the Chicago World's Fair, Niagara Falls, Electric Traction, Steam and Gas Engines, the Turbo-Generator, Signalling and Interlocking, Natural Gas, and European Enterprises.

In each of these enterprises Westinghouse was the leader and in most cases the dominant factor in the development of the art. As the author points out, he had the ability of foreseeing the possibilities of others and the perseverance necessary to make them commercially successful.

His foresight in championing the alternating current is noteworthy. At the present time 95 per cent of the electrical energy developed is alternating current. In 1886 many people fought the introduction of alternating current as a menace to the country.

Chapters on the personality of Westinghouse show clearly his human side in his relations with his men.

A retrospect on the activities of Westinghouse clearly shows that throughout his years of energetic work, his one idea was entirely for public service.

THE PERPETUAL inventory, or stores control system, is strongly urged by the Fabricated Production Department of the Chamber of Commerce of the United States as a better method in manufacturing establishments than the annual physical inventory, with its general disorganization and shutting down of the plant.

A practical treatise on the subject, which has just been issued by the department under the title of "Perpetual Inventory or Stores Control," goes at length into the advantages of perpetual inventory and carries a series of illustrative forms.

Doing away with the annual inventory of materials is only one of a number of benefits derived from the system as set forth by the department. Of this particular boon, it says:

"The perpetual inventory test is an important link in a chain that makes less frequently necessary the burdensome and often inaccurate annual physical inventory. The annual physical inventory entails a general dislocation of plant and frequently a shut-down lasting as long as three to seven days; and the results are not dependable, hence the desirability of eliminating the annual physical inventory as far as possible.

"This is accomplished by independent checking of the material indicated as on hand on the perpetual inventory and bin tag records through a physical count of selected items of stores, and noting and correcting any discrepancies between stock actually on hand and the quantity shown by the bin tag and perpetual inventory records. These inventory tests are made periodically and systematically, preferably at times when the material selected is lowest, and the attempt is made to cover each item of supply at least once a year and important items oftener. It is possible by these tests, as supplementary to the bin tag and perpetual inventory records, to secure an accurate count of material without the burdensome annual inventory."

Copies of the pamphlet may be had in limited quantities free of charge from the Chamber of Commerce of the United States, Mills Building, Washington, D. C.

STURTEVANT generator cooling apparatus is illustrated in Bulletin No. 246 of B. F. Sturtevant Co., Boston, Mass.

THE SARCO CO., INC., of Woolworth Building, New York, has issued a new bulletin, B70, on Temperature Regulators, illustrating various types and their applications.

THE JEFFREY MANUFACTURING CO.'S Catalog No. 359 features the Jeffrey single roll coal crusher for reducing coal, bone, alum, salt and similar materials, as adapted to the power house, the coaling station and the coal mine. The book fully describes and illustrates construction and operation, including typical installations in service, table of capacities of the different sizes of machines for use in crushing various grades of bituminous coal, and other valuable information for crusher users.